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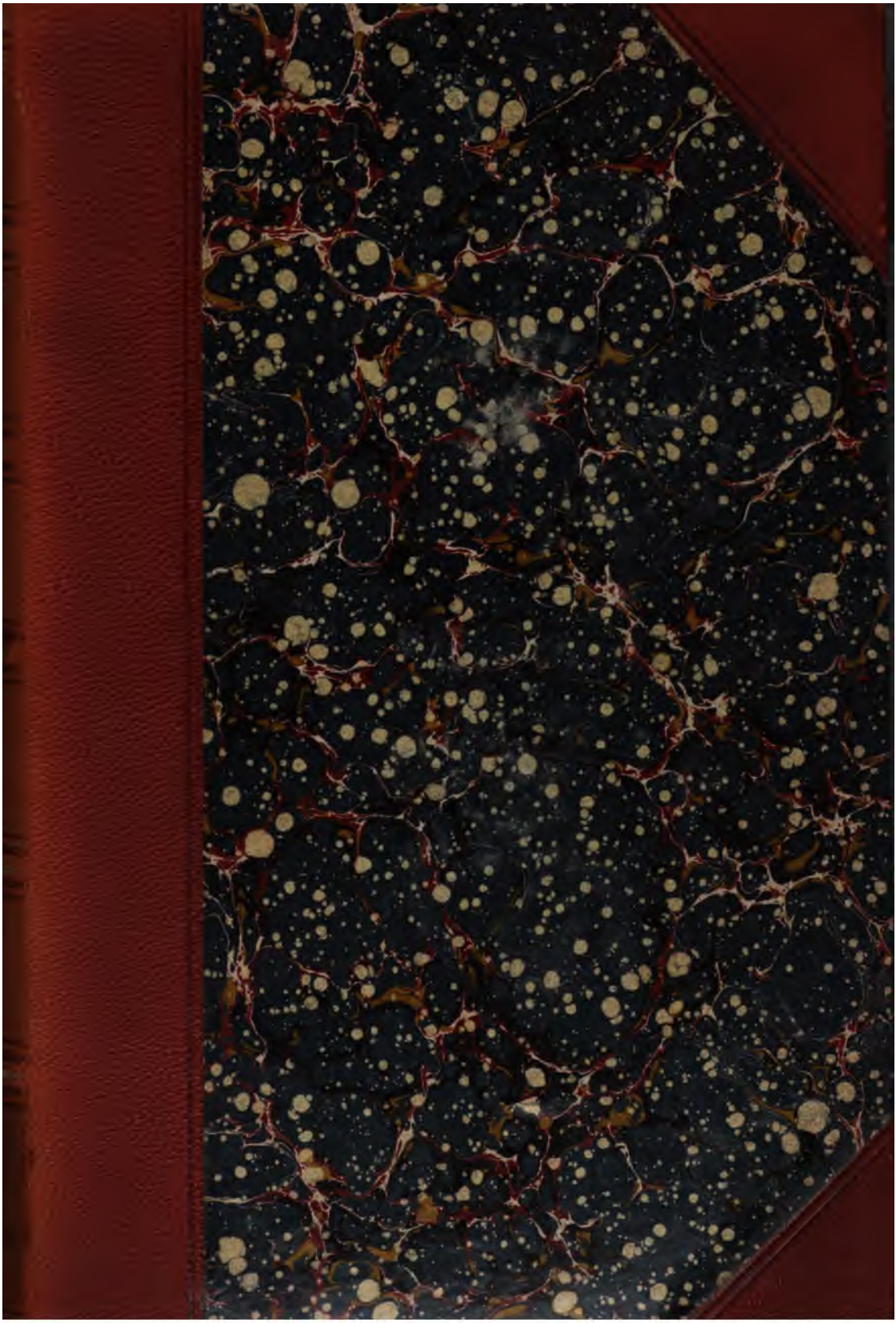

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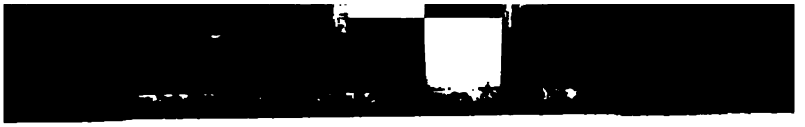

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME SEVENTEENTH,

PARTS I.-XVIII., 1882-83-84.

MANCHESTER:

SOLD AT THE ROOMS OF THE SOCIETY,

36, GEORGE STREET, MANCHESTER.

1884.

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*** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

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ERRATA.

Page 290, 7th line from bottom, Eloin, not Elsin.
„ 291, 4th „ „ top, „ „ „
„ 351, 2nd „ „ „ train, not chain.
„ 370, End of Vol. XVIII., should be XVII.

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MANCHESTER GEOLOGICAL SOCIETY.

Established 15th October, 1838.

OBJECTS.

The objects of the MANCHESTER GEOLOGICAL SOCIETY *are the collection and diffusion of Practical and Theoretical Knowledge respecting Geology and Mining. In furtherance of such objects, original Papers on Geology and Mining subjects—either written by the members of the Society, or communicated to the Society through a member, on behalf of the authors—shall be read and discussed at its meetings, and if judged to be of sufficient interest, shall be printed at the expense of the Society, in its Transactions.*

RULES.

I.—The Society consists of Ordinary, Life, Honorary, and Corresponding Members.

II.—Every candidate for admission into the Society as an ordinary member must be proposed by two or more members, who must sign a certificate in recommendation of him, setting forth the name, description, and place of residence of the candidate.

III.—The certificate, when duly filled up, shall be read aloud at the next ordinary meeting of the Society; and the election of the candidate shall forthwith be decided by a majority of votes.

IV.—The Secretaries shall address to every person elected a member, a notification of such election, with a copy of the printed Rules and Bye-laws of the Society.

V.—No person elected a member shall be entitled to exercise any privilege as such, until he shall have paid his annual subscription, or the composition in lieu thereof.

VI.—The annual subscription to be paid by ordinary members shall be twenty shillings, due on each successive first day of October, and payable in advance for the current year, and shall be a debt due to and recoverable as such by the Treasurer for the time being.

VII.—Members joining the Society on or after the first day of April in any year shall pay the sum of ten shillings as the subscription for the current year.

VIII.—An ordinary member may, at his election, or any future period, become a life member by compounding for future annual subscriptions, including that of the current year, by the payment of ten pounds. If he has already paid the subscription for the current year, or any part of it, such payment shall be allowed in part of his composition.

IX.—The payment by an ordinary or life member of the subscription, or the composition in lieu thereof, shall imply the acquiescence of such member in the Rules and Regulations of the Society, and shall entitle him (so long as no subscriptions remain unpaid) to admission to the meetings of the Society, the use of the Library, and to one copy of each of the Transactions, and of any other publications the Society may print.

X.—Individuals distinguished for their Geological or Mining researches, for their liberality to the Society, or for their connexion with other Societies, may, on the recommendation of the Council, be elected honorary or corresponding members of this Society at any ordinary or general meeting. But such honorary or corresponding members shall have no vote in the affairs of the Society.

XI.—Any member may withdraw from the Society by signifying his wish to do so, by letter under his hand, to the Secretaries, at the apartments of the Society; provided always, that such member shall be liable for the subscription for the whole year wherein he signifies his wish to withdraw; and shall continue liable to future annual subscriptions until he has discharged all sums due from him to the Society, and returned all books and

other property, if any, in his custody, belonging to the Society; or shall have made full compensation for the same if lost or not forthcoming after two months' notice from the Secretaries.

XII.—As soon as any member has let his subscriptions fall two years in arrear, the Secretary shall notify the fact to him, and require him to pay what is due within one month. In case of non-compliance with such request, the Council may determine the membership of the defaulter.

XIII.—An annual meeting of the Society shall be held in the month of October, for the purpose of electing the officers for the current year, receiving the Annual Report of the Council, together with an Audited Statement of the Receipts and Expenditure of the last year, and transacting the general affairs of the Society. At this meeting any member may question the Council upon any matter contained in such report, and comment thereon, and on any other matter of which notice in writing had been previously given to the Council, relating to the affairs of the Society, as to him may appear proper.

XIV.—Ordinary meetings of the Society shall be held once, at least, in every month, from October to June inclusive, at such time as the Council shall appoint. Each member shall have the power to introduce visitors to the meetings, on entering their names in a book to be kept for that purpose.

XV.—Ordinary meetings may be held in other localities than Manchester, according to the pleasure of the Society, to be determined at a previous meeting.

XVI.—Circulars announcing meetings of the Society, or of the Council, shall be sent, free of postage, to the respective members of those bodies, at least three days before such meeting.

XVII.—Special general meetings may be summoned by the Council, or by the Secretaries, on the requisition, in writing, of any six members of the Society, by notice delivered free, or sent by post, pre-paid, to all the members whose addresses are known, not less than one week, nor more than a fortnight, before any such meetings. Such notice shall state the time and place of

holding the meeting, and the specific purposes for which it is convened; and the business of such meeting shall be restricted to such purposes.

XVIII.—At the hour appointed for a meeting of the Society or Council, the chair shall be taken by the President, or the senior Vice-President present, and in their absence the meeting shall, previously to entering upon any other business, elect some member present to be Chairman.

XIX.—All questions discussed at any such meeting, except as otherwise provided, shall be decided by a majority of votes; and if upon any question the votes shall be equal, the Chairman of the meeting shall have a second vote as a casting vote.

XX.—No business shall be done at any such ordinary or special meeting unless when five members at least are present, except that any number of members who may be present, not being less than two, may adjourn the meeting to a future day, such adjourned meeting to be summoned in the same manner as the origina meeting.

XXI.—A President, four Vice-Presidents, two Honorary Secretaries, and a Treasurer, shall be elected at each annual meeting; and the foregoing, together with twelve ordinary members, to be elected at the same time, shall form the Council of the Society, and shall have the management of its affairs, except as is otherwise provided by these Rules; and at the same meeting two Auditors shall be elected for the year ensuing. These elections shall be by ballot. In addition to the four Vice-Presidents annually elected, the Ex-Presidents shall be *ex post officio*, Vice-Presidents of the Society.

XXII.—Any member who has been for six months a member of the Society, and whose subscription is not in arrear, shall be eligible to be elected an officer or member of the Council.

XXIII.—In the event of any vacancy occurring during the year in the Officers or Council, the same shall be filled up by the Council.

XXIV.—The President shall not be eligible for that office for more than two years in succession; and the two Vice-Presidents, and the four members of the Council who shall have attended the meetings of Council the least number of times, shall be ineligible to the same office for the ensuing year.

XXV.—The Council shall have power to make Bye-laws and Regulations, in accordance with the general Rules of the Society, to appoint, suspend, or dismiss salaried agents, clerks, or servants; to purchase and collect books, maps, models, specimens, and other objects; to provide rooms for the meetings of the Society, and pay rent for the same; and to purchase furniture or other articles that they deem necessary for the use of the Society.

XXVI.—The Council shall meet once at least in every month, and upon such other occasions as they may deem expedient. Special meetings of the Council may be called by either of the Secretaries, or on the requisition of any three members of the Council, of which number the officer convening such meeting may be one; any three members of the Council present at a meeting being sufficient to constitute a quorum.

XXVII.—A minute of the proceedings of all meetings shall be entered by the Secretaries in a book to be kept for that purpose.

XXVIII.—The Council shall decide whether a paper shall be printed in the Transactions or not, and if they do not unanimously agree to print it, or reject it, they may refer it to one or more members of the Society, to report upon its merits, and, in exceptional cases, refer it to competent persons who are not members. After having received such reports, the Council shall decide without delay whether or not the paper is to be printed. The author of a paper shall be at liberty to reserve his right of property therein, and shall have a right to withdraw it from publication, by giving timely notice to the Council.

XXIX.—All moneys, the Library, and all chattels of the Society, shall be held by the President and Treasurer for the time being, as legal owners thereof, but in trust for the Society, and

under the direction of the Council, and all investments shall be made in the names of such members, not being less than two, as the Society may from time to time appoint.

XXX.—All the funds and moneys of the Society shall be applied by or under the direction of the Council, in paying the debts and demands for the time being owing by the Society, and carrying out the purposes thereof as defined in the preceding Rules; and no dividend, gift, division, or bonus in money, shall at any time, or under any circumstances, be made unto or between the members of the Society, or any of them.

XXXI.—No additional rule, nor any alteration or repeal of any existing or future rule or rules of the Society shall be made, unless with the consent of three-fourths in number of such of the ordinary and life members as may be present at any annual or special meeting; and the proposed change must be announced by circular to the members whose addresses are known, at least three weeks before such meeting.

XXXII.—The Society shall not be dissolved, nor shall the Library or other property be disposed of, unless with the consent, in writing, of three-fourths of such of the ordinary and life members as may be present at each of two successive special general meetings, duly convened by public advertisement in the Manchester daily newspapers, and by notice sent by post at least one calendar month before each meeting, to all members, whose addresses are known; such meetings to be held at an interval of not less than two, nor more than four, calendar months.

By order of the Council,

BYE-LAWS

FOR

REGULATION OF THE LIBRARY.

I.—No Book, Map, or document shall be taken from the Library without the same being first entered in a Register, in such manner as the Council shall from time to time direct.

II.—The time allowed for retaining a Book, &c., shall not exceed one calendar month.

III.—No member shall be allowed to renew a Volume, Map, &c., in case any other member shall have entered his name as being desirous of taking out the same on its return. Such Volume, Map, &c., shall, on its return from the person holding the same, be entered as taken out by the member so applying, and shall not be taken away by any member, save him in whose name it is entered, till the expiration of the period for which the member in whose name it is entered would have been entitled to hold the same. At which period the said Book, &c., (in case the same shall not have been taken out by the party in whose name it is entered on the Register,) shall be returned in the Register as returned.

IV.—The time allowed for holding shall, in every case, be computed from the date of the entry in the Register.

V.—Every member shall return the Books, Maps, and documents belonging to the Society in as good a condition as when they were delivered into his possession, and shall be answerable for the same till their return from him, to the Society, is correctly entered in the Register.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XVII. SESSION 1882-83.

ANNUAL MEETING.

The ANNUAL MEETING of the Members of the Society was held on Tuesday, the 3rd day of October, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

G. C. GREENWELL, Esq., F.G.S., Vice-President, in the Chair.

The CHAIRMAN stated that a telegram had been received from the President, Mr. Gilroy, who was, he regretted to say, unable to attend on account of indisposition.

The Hon. Secretaries announced that the following Books have been received since the last meeting:—

Reports of the Inspector of Mines, 1881. Special Report on the Abram Explosion, by Mr. A. Young.—*From Hugh Birley, Esq., M.P.* Bristol Naturalists' Society: Part III., Vol. III., N.S.—*From the Society.* Cambridge University: Report of the Museum and Lecture Rooms Syndicate.—Chester Society of Natural Science: Annual Report, 1881-2.—Cornwall, Transactions of the Royal Geological Society of: Part IV., Vol. X.—*From the Society.* Edinburgh Royal Physical Society: Proceedings; Session 1880-1.—*From the Society.* Epping Forest Naturalists' Field Club: Transactions, Parts 5 and 6, Vol. II.—*From the Club.* Geological Magazine: Parts 216-219.—*Purchased.* Hertfordshire Natural History Society: Transactions, April and May, 1882.—*From the Council.* Institution of Mechanical Engineers: No. 2, 1882.—*From the Council.* Lavalley, M., Report on the

Channel Tunnel Railway, 1882.—*From the Author.* Leicester Literary and Philosophical Society: Transactions, Part 8; 1865 to 1870; Report for 1881-2.—*From the Council.* London Geological Society: Quarterly Journal, Nos. 150-1.—*From the Society.* London Geologists' Association, No. 5, Vol. VII.—*From the Council.* London, Royal Society, Nos. 219-21, Vol. XXXIII.—*From the Society.* Manchester Scientific Students' Association: Report and Proceedings for 1881.—*From the Council.* Midland Institute of Engineers: Transactions, LVIII., LX., Vol. VIII.—*From the Council.* Mining Institute of Scotland: Transactions, Parts 2, 3, 4, 5, Vol. IV.—*From the Council.* North of England Institute of Engineers: Transactions, Part 3, Vol. XXI.—*From the Council.* Norwich Geological Society: Proceedings, Part 6, Vol. I. President's Address, 1881.—*From the Society.* Palæontographical Society: Monograph, Vol. XXXVI.—*Purchased.* South Wales Institute of Engineers: Proceedings, No. 1, Vol. XIII. *From the Institute.* Warwickshire Naturalists and Archæologists' Field Club: Proceedings, 1881.—*From the Club.* Bulletin of the Museum of Comparative Zoology: Part I., Crustacea. Do., Vol. IX., Nos. 6-8.—*From Alex. Agassiz.* Smithsonian Institution: Report for 1880.—*From the Institution.* Wisconsin, Geology of, Vol. III.; Survey of, 1873-9; Atlas to Do.—*From the Survey.* Mineral Statistics of Victoria for 1881. Report of the Chief Inspector of Mines (Victoria) for 1881. Quarterly Report of the Mining Surveyors and Registrars, Victoria, March, 1882.—*From the Royal Society, New South Wales.* Der Deutschen Geologischen Gesellschaft: Zetischrift, Band XXXIII., Hefts 3 and 4, 1881.—*From the Society.* L'Académie Imperial des Sciences de St. Petersbourg: Mémoires, VII$_e$ Serie, Mémoires, No. 5, Tome XXVIII.; and No. 5, Tome XXX.—*From the Academy.* Società Toscana di Scienze Naturali: Processi Verbali, Vol. III. (pages 29 to 92), 1881.—*From the Society.* R. Accadamia dei Lincei: Transunti, Vol. VI., Fas. 11°, 14°.—*From the Academy.*

REPORT OF THE COUNCIL FOR 1881-82.

It is with much gratification that, at the end of the Session 1881-2, now concluded, your Council are able to report in favourable terms of the position of the Society and of the work done during the Session.

Several interesting and important papers have been read at the Ordinary Meetings, and the subjects were discussed in a manner which evinces the importance attached to them.

In accordance with the arrangement announced in last

year's Report, two meetings have been held (in the months of January and June) at Wigan, and it is proposed that, during the ensuing Session, there shall be three of the eight Ordinary Meetings held there.

Your Council consider this is a suitable opportunity for bringing before the Members the necessity of continued and increasing exertions in forwarding the work in which they are engaged, in order to maintain the Society in its present rank among similar institutions.

During the past Session the number of Members has continued to increase; 34 new Members have been elected, the loss through deaths and removal 6, leaving a nett gain of 28. The numbers now enrolled are 18 Honorary, 8 Life, and 196 Ordinary Members—total, 222—against 18 Honorary, 8 Life, and 167 Ordinary Members—total, 193, at the same period last year.

The financial position of the Society is also in a satisfactory state, as will be seen by reference to the Treasurer's Balance Sheet. The Credit Balance will be found to have increased from £71 7s. 5d. to £159 2s. 7d. Of this amount it is proposed to add, at an early date, £100 to the sums already invested.

The Library has been considerably increased by the valuable exchanges, presentations, and purchases made during the Session. A list of these additions will be found appended hereto.

Two Excursions were arranged for, and taken part in by some of the members, the district from Portsmouth to Bacup in East Lancashire being the site of the one, and the neighbourhood of Clitheroe, in North-East Lancashire, the other.

The former Excursion to Portsmouth, &c., was made in connection with members of the Scientific Students' Association, and the Literary and Scientific Society of Urmston and Flixton—to whom thanks are due for their cordial reception

of the proposal that it should be a combined excursion—led by one of our Past Presidents, Mr. John Aitken. Our leader delivered an address, pointing out the relative positions and localities in which the coal measures and various grits of the carboniferous measures occur.

The arrangements for the latter Excursion to Clitheroe were principally and efficiently made by Mr. J. F. Seddon. The main features and points of interest, including the patch of Permian measures thrown in by faults, and contorted measures were pointed out and explained by gentlemen locally acquainted with the geology of this part of Lancashire, which contributed largely to the success and interest of the Excursion.

Two pleasant and instructive days were thus spent, but your Council regret that the number of members who took part in them did not reach their expectations.

It is with deep feelings of sorrow your Council have to announce the death of four members during the past session. Mr. E. W. Binney was one of the original founders of the Society in 1838. To eulogise his work is unnecessary, as he was so well known to all. His loss is a serious one to the Society and to geologists generally, but more especially to local geology, upon which he was the most eminent authority of the day. He had also a fair and considerable knowledge of mining. A memoir and list of his contributions to the Society will be found in Part XII., Vol. XVI.

Mr. W. J. Grimshaw, one of your Council, and recently one of the Hon. Secretaries. He took a lively interest in the work of the Society, and contributed several useful and practical papers on subjects connected with mining.

Mr. John Hall, for many years a member, and Mr. John Jobling.

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

Abstract of Receipts.	£	s.	d.	Abstract of Payments.	£	s.	d.
1881-2.—To Balance brought down	71	7	5	1881-2.—By Library	4	11	9
,, Birkenhead Dividends.....	23	10	0	,, Transactions.....	44	14	6
,, Sale of Transactions	2	4	6	,, Reporters....	11	16	0
,, Subscriptions	184	0	0	,, Circulars, Stationery, &c. ..	7	19	2
,, Arrears.....	15	2	0	,, Postages, &c.	22	13	6
,, Bank Interest	0	18	8	,, Collector's Commission	9	19	1
				,, Rent, &c.....	30	0	0
				,, Attendance	2	10	0
				,, Deputation to Mr. Binney's Funeral	3	8	0
				,, Excursion Expenses	0	8	0
				,, Balance in the Bank	159	2	7
	£297	2	7		£297	2	7

1882.
To Balance brought down, due to Society. £159 2 7

The Investments consist of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway in the names of Henry Mere Ormerod and Andrew Knowles.

Audited and found correct, 2nd October, 1882,

HENRY M. ORMEROD, Treasurer.

EDWARD PILKINGTON, Auditor.

27th September, 1882.

The Society further possesses a valuable Library, and there are some arrears of Subscriptions.

	£	s.	d.
Subscriptions received for 1882, No. 183	183	0	0
Ditto at 10s. No. 2	1	0	0
	184	0	0
Arrears received, 1880–1 ..... £9 0 0			
„ „ 1879–80 .. and 2/- 4 2 0			
„ „ 1878–9 ..... 2 0 0			
	15	2	0
	£199	2	0

Arrears remaining, October, 1882:—

Eighteen	for 1881–2	18	0	0
Six	for 1880–1 .....less 2/-	5	18	0
Four	for 1879–80.....	4	0	0
Three	for 1878–9	3	0	0
One	for 1877–8	1	0	0
		£31	18	0

THE FOLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

ORDINARY MEETINGS DURING THE SESSION:—

1881.

December. Clay Deposit at Heaton Mersey.

Discussion "On the Glacial Geology of the District of Llandudno."

Dawkins, Prof., F.R.S., "On the Range of Anodonta Jukesii."

1882.

January.	Binney, E. W., F.R.S. Memoir and List of Papers contributed by him to the Society.
	A New Exploring Respirator.
	New Fan Indicator and Tell-Tale.
	The New Tin-Can Safety Lamp.
	Hilton, James, "On the Long Wall System at Sovereign Pit, West Leigh."
February.	Percy, C. M. "The Kœpe System of Colliery Winding."
	Law, Robert, and James Horsfall, "On the Discovery of Flint Implements on the high hills in the neighbourhood of Rochdale."
March.	Discussion "On the Long Wall System of Working Coal at West Leigh."
	Teale, W. E., "On the Safe Lighting of Collieries."
April.	A New Gas-Detecting Apparatus.
	Discussion "On the Kœpe System of Winding."
	Black, W. J., F.R.C.S.E. "Geology of Pic de Sancy Mountains, Central France."
May.	Note on Flint Implements.
	Dawkins, Prof., F.R.S. "The Channel Tunnel."
June.	The Owens College Museum.
	Watts, William, F.G.S., "On a Section of Coal Measures in Saddleworth."
	Safety Lamps and the Safe Lighting of Collieries.
	Discussion "On the Tin-Can Safety Lamp."
	A New Lamp.
	Ashworth, James, M.E. "An Improved Mueseler Safety Lamp."
	Cockson, Charles, M.E. "Centrifugal Fans: their relative efficiency and useful effects."
	Discussion "On the Safe Lighting of Collieries."
	Discussion "On Tin-Can Lamps."

The Report and Balance Sheet being considered satisfactory were unanimously adopted, and ordered to be printed.

The following noblemen and gentlemen were unanimously elected as Officers and Members of the Council for the ensuing year:—

President:

JOHN AITKEN, J.P.

Vice-Presidents:

WILLIAM BRYHAM, J.P.
W. W. B. HULTON, J.P.
EDWARD PILKINGTON.
MARK STIRRUP, F.G.S.

Ex-Officio Vice-Presidents:

JAMES HEYWOOD, F.R.S.
G. W. ORMEROD, F.G.S.
JOSEPH DICKINSON, F.G.S.
ANDREW KNOWLES.
G. C. GREENWELL, F.G.S.
JOHN KNOWLES, M.Inst.C.E.
THOMAS KNOWLES, M.P.
W. BOYD DAWKINS, F.R.S.
R. CLIFFORD SMITH, F.G.S.
JOHN EDWARD FORBES, F.G.S.
RIGHT HON. THE EARL OF CRAWFORD & BELCARRES.
SIR U. K. SHUTTLEWORTH, BART.
GEORGE GILROY, M.INST.C.E.

Treasurer:

HENRY MERE ORMEROD, F.G.S.

Secretaries:

JOSEPH S. MARTIN, F.G.S. | JOHN E. FORBES, F.G.S.

Other Members of the Council:

J. S. BURROWS,
C. G. GREENWELL, JR., F.G.S.
HENRY HALL.
CHARLES HARDWICK.
JOHN L. HEDLEY.
G. H. HOLLINGWORTH. F.G.S.
CLEGG LIVESEY.
ROOKE PENNINGTON, F.G.S.
J. F. SEDDON.
GEORGE WILD.
E. LEADER WILLIAMS, M.I.,C E.
H. A. WOODWARD.

Auditors:

ALFRED PILKINGTON. | JOHN GREENWOOD, JUN.

Mr. AITKEN having taken the President's chair, said: As the meeting has done me the honour to elect me President for the ensuing year, I rise to thank the Members for the

honour thus conferred upon me. I would much have preferred, had I followed my personal inclination, to have remained in the position I occupied, and not taken so prominent a place as that of your President; but as it seemed to be the general wish of the Society, and my name having been received here with marks of favour, I can only say that I will do my best to discharge the duties during my year of office, and try to maintain the Society in its present vigorous and useful position.

NEW ORDINARY MEMBERS.

Black, W. J., F.R.C.S., Ed.
Bradley, F. L.
Burnett, R. T., F.G.S.
Clark, C. F.
Clark, George.
Cockson, Charles.
Devenport, John.
Gilroy, S. B.
Glover, B. B.
Greenhalgh, Robert.
Gresley, W. S., F.G.S.
Hall, Henry.
Heathcoate, William.
Hilton, J.
Johnson, William.
Kenney, George.
Knowles, Israel.
MacAlpine, G. W.
Merfyn, A.
Pearson, A.
Pennington, A. S.
Percy, C. M.
Rigby, William.
Sacré, R. A.
Settle, Joel.
Smith, John.
Southworth, Thomas.
Stopford, T. B.
Storey, Edward.
Squire, J. B., A.Inst.C.E.
Walker, T. A.
Wall, Henry.
Wallwork, Thomas.
Wanless, William.

MEMBERS DECEASED.

Binney, E. W., F.R.S., F.G.S.
Grimshaw, W. J., F.G.S.
Hall, John.
Jobling, John.

MEMBERS RESIGNED, &c.

Byrom, W. A.
Wheeler, H. G.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey-, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-2-3, 77-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.Inst.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1878-9	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.

LIST OF MEMBERS.

OCTOBER, 1882.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachusetts, U.S.A.
1863	Aitken, John, J.P., Clifton Villas, Urmston. *President.*
1879	Arrandale, John Thomas, Bradford Colliery, Manchester.
1877	Arthur, David, Baxendale Collieries, near Accrington.
1865	Ashworth, Edward, Stag Hills, Waterfoot, near Manchester.
1878	Ashworth, James, Mapperley Colliery, West Hallam, Derby.
1878	Ashworth, Thomas, 32, St. Ann's Street, Manchester.
1877	Atherton, James, 16, Acresfield, Bolton.
1878	Atkinson, Samuel C., Stand Lane Colliery, Radcliffe.
1878	Atkinson, W. N., H.M. Inspector of Mines, Shincliffe Hall, Durham.
1881	Aubrey, Richard Charles, Standish, near Wigan.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1876	Barnes, R. J., Scarsdale House, Ripley, near Derby.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool.
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1879	Baxter, Henry, Tyldesley Colliery, Tyldesley.
1858	Bazley, Sir Thomas, Bart., Eyford Park, Stow-on-the-Wold, Gloucestershire.
1877	Beswick, James, Shakerley Collieries, Tyldesley.
1881	Black, W. J., F.R.C.S.Ed., F.G.S.Ed., 2, George's Square, Edinburgh.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., Newchurch, near Manchester.
1880	Boot, John Thomas, The Orchards, Hucknall Huthwaite, near Mansfield.

Year of Election.	
1878	Bradford, the Right Hon. the Earl of, Weston Park, near Shifnal.
1882	Bradley, F. Lewis, Bel-Air, Alderley Edge.
1878	Brocklehurst, Thomas, Dean, Bolton.
1877	*Broeck, Ernest Vanden*, 124, Rue Terre Neuve, Brussells.
1880	Bromley, Thomas, 17, Hind's Fold, Elton, Bury.
1877	*Brongniart, Charles*, Museum d'Histoire Naturelle, 57, Rue Cuvier, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1880	Brown, Wm. Speakman, 14, Trevelyn Bank, Abbey Grove, Eccles.
1859	Bryham, William, J.P., Ince Hall, Wigan. *Vice-President.*
1881	Bryham, Wm., jun., Douglas Bank Colliery, Wigan.
1862	*Buccleuch, His Grace the Duke of, Whitehall Gardens, London, S.W.
1882	Burnett, R. T., F.G.S., 10, Stanley Avenue, Eccles.
1879	Burns, Thomas, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., Yew Tree House, Atherton, near Manchester. *Member of Council.*
1879	Carter, James, 1, Granville Terrace, Blackburn.
1881	Clark, Christopher F., Park Lane Colliery, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1878	Clayton, Abel, 11, Chapel Walks, Manchester.
1882	Cockson, Charles, Wigan Coal and Iron Company, Wigan.
1878	Cooke, Charles, Marehay Main Colliery, Ripley, near Derby.
1859	*Coulthart, John Ross, F.R.S.Lit., F.S.A.Scot., Croft House, Ashton-under-Lyne.
1878	Cowburn, Henry, West Leigh, near Manchester.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1880	Crompton, William, Ince, near Wigan.
1862	Cross, John, 77, King Street, Manchester.

Year of Election.	
1860	Crowther, Samuel, Bradford Estate Office, Bolton.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Past-President.*
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley.
1882	Devonport, John, Chamber Collieries, Oldham.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Past-President.*
1879	Dixon, Charles William, 19, King Street, Wigan.
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1880	Duncan, William, M.D., Prospect House, Tyldesley.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, Worsley Old Hall, near Manchester.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskillen, The Right Hon. the Earl of*, F.R.S., Florence Court, Fermanagh.
1865	Evans, Walter, Longsight, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1880	Fairley, Joseph Smith, 64, Victoria Street, Liverpool.
1863	Farrar, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1857	Forbes, John Edward, F.G.S., 46, Hyde Road, Manchester. *Past-President, and Hon. Secretary.*
1873	Garforth, W. E., Colliery Offices, Normanton.

Year of Election.	
1874	*Geikie, Archibald*, LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy, George, M.Inst.C.E., Hindley Hall, Wigan. *Past-President.*
1881	Gilroy, Samuel B., Mining Engineer, Cheetham Hill, Manchester.
1882	Glover, B. B., Haydock, near St. Helens.
1881	Goodall, John, Birley Collieries, near Sheffield.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1882	Gresley, W. Stuckley, F.G.S., Overseal, Ashby-de-la-Zouch.
1863	Greenwell, G. C., F.G.S, Duffield, Derby. *Past President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport. *Member of Council.*
1879	Greenwood, John, jun., Ashton Moss Colliery, Audenshaw, Manchester. *Hon. Auditor.*
1879	Gregson, Edward, 11, Chapel Street, Preston.
1880	Grimke, Theodore Drayton, Whitledgehurst, Ashton-in-Makerfield.
1880	Grimshaw, H. Stott, Stand Lane Colliery, Radcliffe.
1877	Grundy, H. T., Radcliffe.
1877	Grundy, Joseph, Radcliffe.
1879	*Guibal, Theophile*, Professeur d'Exploitation des Mines, Mons, Belgium.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot. *Member of Council.*
1864	Hall, Robert, Hope Foundry, Bury.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester. *Member of Council.*
1880	Hargreaves, John, Winkhill, near Leek, Staffordshire.
1875	*Hawkins, B. W.*, F.G.S., 13, Burnand Street, Regent's Park, London, N.W.

Year of Election.	
1874	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.*, State Geologist, Washington, U.S.A.
1882	Heathcote, William, Farnworth, near Bolton.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester. *Member of Council.*
1875	Hetherington, Joseph. 22, Booth Street, Manchester.
1874	Hewlett, W. H., Wigan Coal and Iron Company, Wigan.
1880	Heys, James, Westleigh, Leigh, near Manchester.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Past-President.*
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, J., Wigan Coal and Iron Company, Wigan.
1881	Hodgekiss, John, Downall Green Colliery, Ashton, near Wigan.
1878	Holden, Charles H., Mawdseley Street, Bolton.
1877	Holding, William, Crossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., Hollinwood, Manchester. *Member of Council.*
1878	Howell, John, Astley, near Manchester.
1874	*Hull, Professor Edward*, M.A., F.R.S., 5, Raglan Road, Dublin.
1880	Hulton, W. W. B., J.P., Hulton Park, near Bolton. *Vice-President.*
1878	Jackson, Charles G., Chamber Colliery Offices, Hollinwood, Manchester.
1875	Jackson, J., 5, Wood Street, Bolton.
1877	Jackson, Lewis, Rocher Colliery, Ashton-under-Lyne.
1880	Jackson, William, Bower Colliery, Hollinwood, Manchester.
1880	Jeffcock, Charles Edward, High Hazels, Sheffield.
1879	Johnson, Isaiah, Llangennech Coal Company, Llanelly.
1882	Johnson, William, Abram Colliery, Wigan.

Year of Election.	
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1880	Kennedy, Matthew, Brinsop Hall Collieries, Wigan.
1882	Kenney, George, 11, King Street, Wigan.
1879	*Kinahan, G. H.*, M.R.I.A., Lurgybrack, Letterkenny, Ireland.
1856	Knowles, Andrew, High Bank, Pendlebury. *Past-President.*
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury. *Past-President.*
1882	Knowles, Israel, Wigan.
1877	Knowles, Lees, M.A., LL.M., Westwood, Pendlebury.
1858	Knowles, Thomas, M.P., Darnhall Hall, Winsford, Cheshire. *Past-President.*
1858	Lancaster, John, F.G.S., Bilton Grange, Rugby.
1862	Livesey, Clegg, Woodley, Stockport. *Member of Council.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1878	Longbotham, Jonathan, Norley Colliery, Wigan.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., M.Inst.C.E., Crossgates, near Leeds.
1861	Lynde, J. G., F.G.S., Gore Street, Greenheys, Manchester.
1881	MacAlpine, G. W., Whinney Hill Colliery, Accrington.
1878	Maiden, Sampson, Bridgewater Villas, Stockport.
1873	Martin, Joseph S., F.G.S., H.M. Inspector of Mines, Park Villas, Prestwich. *Hon. Secretary.*
1879	Melling, William, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1881	Merfyn, A., care of Messrs. Higson, 18, Booth Street, Manchester.
1876	Moore, Alfred, C.E., 5, Clarence Street, Manchester.
1838	*Morton, Charles*, The Grange, Southport.
1874	*Morton, G. H.*, F.G.S., 122, London Road, Liverpool.

Year of Election.	
1878	Nall, Simon, Newbold, Rochdale.
1878	Nelson, William, Leigh, near Manchester.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1838	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth. *Past President.*
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester. *Hon. Treasurer.*
1874	*Owen, Professor Richard*, D.C.L., F.R.S., &c., South Kensington Natural History Museum, London.
1862	Park, James, Fern Hill, Bury.
1880	Parish, Arthur Woodbyne, Clowes House, Higher Broughton, Manchester.
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grove, Eccles.
1877	Peace, Maskell, W., F.G.S., Wigan.
1881	Pearson, A., Dukinfield Cottage, near Ashton-under-Lyne.
1876	Penman, J. Hugh, 2, Clarence Buildings, Booth Street, Manchester.
1881	Pennington, A. S., Wood Street, Bolton.
1877	Pennington, Rooke, F.G.S., 20, Mawdsley, Street, Bolton. *Member of Council.*
1882	Percy, C. M., King Street, Wigan.
1878	Perrin, J. Beswick, M.R.C.S.E., F.L.S., Leigh, near Manchester.
1879	Phillips, Herbert, Digby Collieries, near Nottingham.
1861	Pickup, Peter, F.G.S., Towneley Colliery, Burnley.
1877	Pickup, Peter Wright, Dunkenhalgh Collieries, Church, near Accrington.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester, *Hon. Auditor.*
1879	Pilkington, Charles, Ashton and Edge Green Collieries, St. Helens.

Year of Election.	
1873	Pilkington, Edward, Clifton Collieries, near Manchester. *Vice-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Astley Deep Pit, Dukinfield.
1874	*Ramsay, Sir A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton.
1882	Rigby, William, Leader's Buildings, King Street, Wigan.
1877	Robins, George, Ashton, near Newton-le-Willows.
1882	Sacré, R. A., 20, Cooper Street, Manchester.
1880	*Schofield, Christopher James, Whalley Villa, Whalley Range, Manchester.
1881	School of Mines, Columbia College, New York. The President (for the time being) of the. (To be addressed to Mr. H. Grevel, 33, King Street, Covent Garden, London.)
1873	Seddon, J. F., Great Harwood Collieries, Accrington. *Member of Council.*
1866	Selby, Atherton, Mining Engineer, Leigh.
1882	Settle, Joel, Darcy Lever Collieries, Bolton.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	Smethurst, William, F.G.S., Garswood Hall Colliery, Ashton, near Wigan.
1838	Smith, G. F., M.A., F.G.S., Grovehurst, Tunbridge Wells.
1881	Smith, John, Bickershaw Collieries, Westleigh.
1873	*Smith, R. Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Past-President.*
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.

Year of Election.	
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1882	Stopford, T. R., Park Hall Colliery, Blackrod, Lancashire.
1882	Storey, Edward, Leigh, Lancashire.
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1862	Spence, Peter, F.C.S., Erlington House, Seymour Grove, Old Trafford.
1881	Squire, J. B., A.Inst.C.E., 1, Milton Road, Herne Hill, London, S.E.
1859	Statter, Thomas, Stand Hall, Bury.
1878	Stephens, James Henry, Leigh, near Manchester.
1880	Stirrup, Mark, F.G.S., Richmond Hill, Bowdon. *Vice-President.*
1881	Taylor, Alfred, Norley Collieries, Wigan.
1880	Teale, William E., Fern Bank, Worsley.
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1878	Tonge, James, F.G.S., Woodbine House, Westhoughton, near Bolton.
1876	Topping, Walter, Bamfurlong Collieries, near Wigan.
1858	*Trafford, Sir Humphrey de, Bart., Trafford Park, Manchester.
1876	Unsworth, John, Scott Lane Collieries, near Wigan.
1879	Unsworth, Richard, Mesne Lea Colliery, Worsley.
1877	Waddington, Henry, Burnley Collieries, Burnley.
1877	Waddington, John, Burnley Collieries, Burnley.
1862	Wadham, Edward, Millwood, Dalton-in-Furness.
1882	Wall, Henry, 11, King Street, Wigan.
1882	Wallworth, Thomas, Colliery Office, Walkden, near Bolton.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.

Year of Election.	
1881	Wanlass, William, New Colliery, Westhoughton, near Bolton.
1879	Warburton, William, High Lane, near Stockport.
1880	Watts, Wm., F.G.S., Piethorne, Rochdale.
1878	Wells, Samuel B., 130, Bradford Street, Haulgh, Bolton.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1880	Williams, E. Leader, M.Inst.C.E., Queen's Chambers, John Dalton Street, Manchester. *Member of Council.*
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne. *Member of Council.*
1877	Wild, Joseph, 3, Stoneclough Road, Kearsley, near Bolton.
1876	Winstanley, Robert, 32, St. Ann's Street, Manchester.
1876	Woodward, H. A., Clifton, near Manchester. *Member of Council.*
1877	Yates, T. M., Anderton Hall, Colliery, Blackrod, Chorley.

Members are requested to communicate immediately to the Hon. Secretaries all changes of Residences.

PRESENTATIONS TO THE LIBRARY, 1881-82.

Birley, Hugh, M.P.—Reports of the Inspectors of Mines, 1881. Special Report on the Abram Explosion, by Mr. A. Young. *From Hugh Birley, Esq., M.P.*

Belfast.—Natural History and Philosophical Society. Proceedings for Session 1880-81. *From the Society.*

Bristol Naturalists' Society.—Part III., Vol. III., N.S. *From the Society.*

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SOCIETIES WITH WHOM THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHOM A COPY IS SENT FREE.

I.—ENGLAND.

London	British Museum.
	Geological Society.
	Geological Survey.
	Geologists' Association.
	Institute of Mechanical Engineers, Victoria Street, S.W.
	Iron and Steel Institute.
	Royal Institution.
	Royal Society.
Manchester	Field Naturalists' Society.
	Free Library.
	Literary and Philosophical Society.
	Owens College.
	Scientific Students' Association.
	Salford Royal Museum and Library.
Barnsley	Midland Institute of Mining Engineers.
Birmingham	Free Library and Museum.
Bristol	Naturalists' Society.
Camborne	Miners' Association of Cornwall and Devon.
Cambridge	Geological Museum, University.
	University Library.
Chester	Society of Natural Science.
Chesterfield	Institute of Mining Engineers, &c. (in bound vols.)
Cornwall	Royal Geological Society, Penzance.
	Royal Institution, Truro.
Dudley	South Staffordshire and East Worcestershire Institute of Mining Engineers.
Exeter	Albert Memorial Museum.
Leeds	Geological and Polytechnic Society.
	Philosophical and Literary Society.
Leicester	Literary and Philosophical Society.
Liverpool	Free Library and Museum.
	Geological Society.

Newcastle-on-Tyne..Institute of Mining and Mechanical Engineers.
Oxford.....Bodleian Library.
Radcliffe Library.
North Shields ....Public Free Library.
Snaresbrook.....The Epping Forest and County of Essex Naturalists' Field Club.
Stoke-on-Trent....North Staffordshire Institute of Mining and Mechanical Engineers.
Swansea .....South Wales Institute of Mining and Mechanical Engineers.
Warwick .....Natural History Society.
Watford, Herts. ..Natural History Society and Field Club.
Wigan .....Free Library.
Mining School.

II.—Scotland.

Dundee.....Free Library and Museum.
Edinburgh .....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.
Glasgow .....Geological Society.
Natural History Society.
Hamilton.....Mining Institute of Scotland.

III.—Ireland.

Dublin.....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
Belfast.....Natural History Society.

IV.—Australia.

Melbourne.....Public Library of Victoria.
Sydney.....Free Public Library.
Royal Society of N. S. Wales.
Newcastle.....John Mackenzie, F.G.S.

CANADA AND UNITED STATES.

Montreal .....Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
M'Gill College (Principal, J. W. Dawson, F.G.S.)
Toronto.....Canadian Institute.
Albany, U.S. ....Verplanck Colvin.
Boston, U.S. ....Free Library.
Columbus, U.S. ..Ohio, Geographical Survey of (Dr. J. S. Newberry).
Easton, U.S. ....American Institute of Mining Engineers.
Indianapolis, U.S..E. T. Cox, State Geologist.
Newhaven, U.S. ..Professor O. C. Marsh, F.G.S.
New York .....American Museum of Natural History, Central Park.
Washington, U.S..Department of the Interior U.S. Geological Survey.
Smithsonian Institution.

VI.—FOREIGN SOCIETIES.

Berlin .....Geological Society of Germany.
Buenos Ayres ....Officiana Nacional de Commercie.
Calcutta .....Geological Survey of India.
Christiania .....Royal University of Norway.
Halle, A.S......Verein fur Erdkunde.
Lausanne (*Suisse*)..Sociétié Vaudoise des Sciences Naturelles.
Lille.....Société Géologique du Nord.
Pisa.....Sociata di Scienci Naturali.
Rio de Janeiro....Museu Nacional.
St. Petersburg....Academy Imperial.
Turin ....Academie Royale.

VII.—SCIENTIFIC JOURNALS, &C.

Geological Magazine, Geological Record, Mining Journal, Colliery Guardian, Iron and Coal Trades Review.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XVII. SESSION 1882-83.

At the ORDINARY MEETING of the Members of the Society, held on Friday, the 3rd day of November, in the Council Chamber, Municipal Buildings, Wigan.

J. L. HEDLEY, Esq., H.M. Inspector of Mines, in the Chair.

THE MEASUREMENT OF AIR CURRENTS.

BY MR. JOSEPH THOMPSON.

There ought not to be—and presumably there is not—anything within the range of the practical applications of science which commends itself more and is of greater interest to those engaged in, and who are responsible for the safety of our coal mines, than a consideration of such appliances as are calculated to impart useful information for their guidance in respect to matters bearing upon the safety of life and property; and it may be added that the efforts which societies make by the discussion of matters brought before them, can aim at no higher practical result, or at one more likely to impart a greater degree of satisfaction than such as tend in that direction.

Among the numerous sources of anxiety inseparably connected with the practice of coal mining, there is probably none which so much exercises the minds of colliery owners and officials as that of the question of ventilation; hence it may be assumed that suggestions bearing upon that subject with any degree of practical importance are not unlikely to prove more acceptable always than is the case in respect of matters necessarily of a secondary character.

The possibility of the occurrence of an explosion is an event of far too serious a nature to be in any way lightly considered; hence it is that coal proprietors have in many cases—during recent years more particularly—been unsparing in the provision of capital for the establishment of the most efficient appliances, by means of which, in some cases, volumes of air are now produced in mines, represented by figures in the hundreds of thousands of cubic feet per minute.

In an abstract sense it may perhaps be stated that, by the establishing of such powerful means of producing ventilation, the duty of mine owners has been abundantly discharged, and there the duty of the officials begin, an important feature of which is that of ensuring that the useful effect intended by the erection of such costly appliances is constantly attained. It cannot indeed be refuted that one of the highest and most important functions of a colliery manager—in a general sense—is a careful observation of the operation of such forces as are known to have a tendency to influence the quantity or volume of air in circulation within the mine, relying—as is the universal practice at the present day—upon the process of dilution for the efficiency of our system of ventilation.

The barometer, thermometer, hygrometer, and water guage are consulted respectively, in order to ascertain the

conditions of pressure, temperature, moisture, and resistance, and an anemometer is used (which for immediate purposes is probably of as great, or greater, importance than any) in reference to quantity of air.

Without derogating in the least the great importance which is attached to the use of the other of these instruments, it may safely be stated that for immediate purposes, at *any* mine, the indications of the anemometer are of the highest importance. Its duty is to indicate effect: the study of the other instruments being concerned with the explanation of cause.

It is therefore a most reasonable ground for regret—if not of something less sentimental—to reflect that the anemometer is, as a rule, the least reliable in its indications of any of the instruments in use, and that probably less system is observed, and a less degree of accuracy attained, than is the case with either the barometer or any of such other of the instruments which I have named.

The indications of most of the forms of anemometer which I have seen used in mines must be regarded as equivocal, and consequently of an unsatisfactory character. The task of making observations is one, moreover, which is attended with some labour, and not reasonably practicable to be performed with that ease and frequency which under more favourable circumstances might be considered desirable.

A much greater scientific value would attach to observations of all the instruments, if those observations were made simultaneously at fixed periods during each day, but before such can be possible it is manifestly necessary that some superior form of anemometer must be adopted, and the observation of its indications rendered as easy as are those of the other instruments.

This being done—and that is really what is involved in

the proposals I am about to submit for your consideration—it must be clear to everyone that at any moment, either by day or night, a perfect knowledge—not only of the operations of the natural forces which affect ventilation, but also of the actual amount of air circulating in the mine—is attainable by the expenditure of a few minutes' labour.

The importance in a practical sense of being constantly able to indicate in the office at the surface the quantity of air passing through a mine, and, in a scientific sense, of the simultaneous system of making all observations, cannot be exaggerated.

The late Mr. William Peace, of Haigh Colliery—formerly a Member of this Society, and one whose opinion on mining matters was always held in the highest esteem—was alive to this importance twenty-five years ago, and designed, patented, and applied an ingeniously constructed anemometer, which indicated on the surface.

Others have interested themselves since that time in the same direction, but it would appear that none, so far as I am aware, have hitherto obtained sufficient favour to secure their general adoption.

Various causes could be stated as accounting for this, but with the increasing concern which science—in its modern form of development—takes in mining matters, and the increased strictures imposed upon mine owners by recent legislation, the necessity constantly grows for increased watchfulness in all respects, and particularly in respect to the very important question of ventilation. That which twenty-five years ago might be regarded as a desirability only may be looked upon to-day as an absolute necessity.

The means which are proposed to be used for indicating at one point the velocity of the air current at some other (and it is important to remember that anemometers are only velocity indicators) is not the result of any new and

important discovery, and will not present, I think, any complex features, or involve anything which it is not easy for everyone to understand.

It is simply an adaptation or combination of already well-known principles and appliances for the accomplishment of the purpose in view; and, having regard to the error which some have made, who have exerted themselves in the same direction, of aiming at results too high, involving costs which have proved fatal to the application of their designs, I have contented myself by simply rendering velocity data attainable with ease, and keeping the probable cost of the apparatus so low as not in any way to constitute a barrier or objection to its adoption.

In the first place, I adopt the use of what in meteorological circles are well known as Robinson's cups; and while many of you must be well acquainted with the nature of their construction, it may still not be undesirable briefly to explain that they consist of four hemispherical metal cups, with their open sides all turned the same way, and mounted at the extremities of two arms crossing at right angles and fixed upon a verticle axle. When they are erected the wind acts on the concave sides presented to it, and thus sets the whole in rotation.

A very important feature is that the speed of the cups always bears the same proportion to that of the wind, not being equivocal, as has been stated, of other forms of anemometers. Of the merits of this form of instrument over any other, it might be sufficient to refer to the fact that it is the only one now in general use among meteorologists, but it may further be added that Mr. Scott, chief of the Meteorological Department at the Board of Trade, in describing it, recently stated that it was "*practically the only velocity anemometer now in use.*"

These Robinson's anemometers, as made for use at obser-

vatories, have a train of wheels connected with the axle of the cups, to register the wind in miles which has passed over them, but these I dispense with, and, instead of registering the wind in miles by clock-work, I cause every revolution of the cups to make and break an electric circuit, to the scope of which there is of course no practical limit.

This is accomplished by a simple mechanical arrangement (connected with the axle of the cups) and an electric armature, and so arranged that the circuit is complete, only each revolution of the cups, a sufficient time to actuate a small "dead beat" hammer upon a surface of porcelain or glass at the observing station.

This hammer and its accompanying apparatus would be enclosed in a wooden box, only a few inches square, the lid of which would have an attached crank or switch, to make and break the electric circuit a second time as the lid was opened and closed. By this means the entire apparatus would be completely free from electric influences, except during the short time occupied in making observations, which in an economic sense is a point of some importance.

The number of beats given by the hammer in one minute—or the average of a number of minutes—representing the number of revolutions of the cups per minute, being ascertained, and the ratio of the speed of the cups to the true velocity of the wind, as well as the superficial area of the station of the cups being known, the number of cubic feet per minute of air passing that point is readily ascertained by a process of calculation as simple as is the case with other forms of anemometer. Tables could moreover easily be drawn up for the purpose of facilitating calculations.

It is not undesirable to note that the electric circuit permits the establishment of a number of observing stations

upon it, and that even in the absence of such stations below ground, it would generally be found practicable to count the revolutions of the cups, or at least for an accustomed eye to form some general comparative estimate of the quantity of air passing, if one out of the four cups was painted white, and the remainder left black.

The method of the erection of the cups at the selected station within the mine is a matter which obviously will be governed by circumstances.

If fixed at a point frequented only by officials in the course of making their inspections—which is certainly a most desirable position—no difficulty of any kind presents itself, and even if no suitable position could be fixed upon, except where the ordinary traffic of the mine was conducted, no serious or insuperable difficulty in the large majority of cases will arise, for, as will be clear to you from the explanation given, but little vertical space will be occupied beyond that of the diameter of the cups, and an iron bearer stretching across the place to support the bottom bearing of their axle.

From this brief explanation it is to be seen that the advantages attendant upon the use of the best—not to say the only reliable—form of anemometer are by the aid of applied electric science, placed within the reach of mine owners and managers, and that, instead of an untimely, unreliable report of the quantity of air passing through their mines, a thoroughly trustworthy account is made accessible to them at any moment.

Taking into consideration the constant changes, or the constant liability to changes, in matters relating to and affecting the ventilation of mines, the receiving to-day an account of the quantity of air which was circulating twenty-four hours previously, must manifestly be of little immediate practical use, the all-important question inva-

riably being, "What is the present condition of affairs?" or "What is going on at the present moment?" The instrument which I have described is always ready to answer this important question, and is really to the managers of mines—in ventilation matters—what a steam pressure guage is to an engine driver, and is the faithful indicator of the degree of constancy in the ventilation, spoken of in the first general rule of the Mines Regulation Act, and to comply with which, as I previously stated, vast sums of money are not unfrequently expended.

It enables a constant check to be kept upon the operations of the fan-minder, or other ventilating apparatus man. It is less liable to get out of order than most other forms of anemometer; a material saving of valuable officials' time—which is said to represent money—is effected, and by supplying an hitherto practically absent item of evidence, renders a simultaneous system of scientific observations of everything pertaining to the ventilation of mines easily practicable, from a study of which useful deductions may doubtless be drawn, and a greater variety of phenomena in connection with the subject probably be developed—a consideration in itself which, it must be owned, is not by any means to be despised.

Having in view these apparent advantages, and taking into consideration that the cost of the requisite appliances is not likely to furnish a stumbling block to their adoption, it may, I think, not unreasonably be anticipated that my observations will prove to be the means of causing some, at least, to turn their attention to the importance of the subject.

There is much room for improvement in the character of other instruments in use in connection with the ventilation of mines beside the anemometer, as well as in the methods of making and recording observations, and there cannot

surely be found any study more fitted to the mind of mining officials than that of the natural forces which affect ventilation.

I shall of course be most happy to impart any further information I am able to do on the subject, and to hear any statement or discussion upon any objections which may occur to any of you touching the practicability, or otherwise, of the proposals which you have been patient enough to listen to.

The discussion on the paper was adjourned.

CENTRIFUGAL FANS.

The discussion on Mr. Charles Cockson's paper was resumed. (See Part xviii., Vol. xvi.)

Mr. C. M. Percy called attention to the special features of the Guibal, Waddell, and Schiele fans referred to in the discussion on this paper. He looked upon the paper as a very important one, and the manner in which it is treated displayed so much ability that one must hesitate before expressing views at variance with the writer. He quite agreed with Mr. Cockson that the practical results from various fans were so contradictory that one almost lost hope of being able to determine the best fan by practical experiments. Mines varied to so great an extent that one fan might be worked under favourable, while another would be under unfavourable circumstances, thereby preventing practical results to decide which was the best under all circumstances. He did not agree with Mr. Cockson that the Guibal fan was so much better than the Waddell and Schiele, as his paper would lead us to

think. His own feeling was that the Guibal fan was wrong in construction, for two reasons. The blades are constructed in a most peculiar fashion; they are inclined backwards, and then curved forwards, and it appeared to him that it was either wrong to do one or the other, and the effect upon the air must be injurious. Another defect has been found in the fact that the air could only make its escape at one part of the fan. He conceived that the Waddell fan was preferable, in that the passages are nicely curved and proportionate, so that the area at the tips agreed with the area at the centre. He had thought it more a correct fan than the Guibal, and the fact that it could expel its air at any point of the circumference appeared correct. But the results did not appear to be as satisfactory as those of some of the others. He thought a Waddell fan fixed horizontally, the passages curved backwards and bell mouthing at the periphery dispensed with, would show good results. The fan of the three named, and constructed as he thought on the best principles, is the Schiele fan. It had an expanding chimney in the form of a spiral casing, which enabled free and easy discharge of the air; not at one point only, but all round the circumference. And the narrowed blades, inclined and curved back, were more correct in shape than the contradictory form of Guibal blades. It is a small fan, and if they are able to produce the requisite quantity with a small fan, it seemed a mistake to have a large one.

Mr. Cockson, in reply, contended that the inclination of the blades of the Guibal fan was perfectly right. The fact was, the Schiele blades were right for the Schiele, and the Guibal blades were right for the Guibal; and as the Schiele fan was practically an open running fan, it could only give the water guage or pressure which any open running fan would produce. The Guibal fan, on the

other hand, gave a much greater water guage at the same speed. He maintained that the curvature of the blades was correct, just as the shape of the Schiele fan blades was right for that type of fan. One was, in effect, an open running fan and the other a closed fan.

Mr. W. J. GREENER expressed his opinion that insufficient attention was often paid to the importance of keeping good open airways. The consequence of neglect was that very frequently a fan was brought into use and failed to answer the expectations that had been formed respecting it.

Mr. WALTER TOPPING suggested that it might be possible to work with duplicated small fans, instead of one large fan. He did not express an opinion that it was possible, but it might be found that equivalent results could be obtained with two small fans as with one large one.

The discussion was again adjourned.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XVII. SESSION 1882-83.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 5th day of December, 1882, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., J.P., President,
in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected ordinary members of the Society:—

Mr. GEORGE CALDWELL, Moss Hall Collieries, Wigan.
Mr. JAMES CUNLIFFE, Bridgewater Collieries, Walkden.

THE OWENS COLLEGE MUSEUM.

The PRESIDENT said it would be interesting to the members to know that the arrangement which was some years ago entered into between this Society and the Manchester Natural History Society on the one hand, and Owens College on the other, was likely soon to be carried out. In 1869 the two Societies agreed to hand over their Natural History and Geological Collections to the Extension Committee of Owens College, on condition that that com-

mittee, within four years, provided accommodation for them, and that the public were admitted to view the collections on certain days of the week free of charge. The Extension Committee, however, on account of the heavy demands upon them in respect of the College, found themselves unable to carry out their part of the arrangement; but they gave an assurance that at no distant period they would do so, and would also provide rooms for other collections of which they had become possessed. He had pleasure, now, in being able to inform the members that the difficulties which had hitherto stood in the way of carrying out that arrangement were in a fair way of being overcome. At a representative meeting held in the Manchester Town Hall a fortnight ago, the Mayor presiding, a committee was appointed to raise the necessary funds for building a new museum; the plans had already been prepared by Mr. Waterhouse, and they might hope within a reasonable period to see the new structure rise above the ground. The building would be of such a character as would offer every facility for the proper display of all the collections, and it would also, he was sure, be an ornament and a credit to the city of Manchester.

THE PERMIAN ROCKS, SOUTH OF MANCHESTER.

PROFESSOR BOYD DAWKINS called the attention of the Society to the discovery of a new area of Permian and coal-measure rocks south of Manchester. The Permian fossiliferous marls and sandstones have been penetrated by the sewers now being made in Mauldeth Road, and in Burnage Lane, Withington, and the Ardwick limestone with its characteristic *spirorbis carbonarius* in Burnage Lane, north of Cringle Brook. Both these rocks are in the area assigned to the pebble beds,

or Lower New Red Sandstone in the Maps of the Geological Survey. He proposes to bring a detailed account of the discovery before the Society when the sewers are sufficiently advanced to allow of his mapping the rocks in question which lie buried beneath from 15 to 20 feet of sand and clay.

Mr. BURNETT observed that, in a boring at Deakin's Brewery, not very far from the locality mentioned by Prof. Dawkins, the Permian Marls were reached, at a depth of about 250 feet. This showed that there must have been a great uprising of the Permian Marl in the direction indicated.

Mr. DICKINSON said that near where the Manchester City Gaol is built the Ardwick limestones were worked some years ago, but that was considerably further north than the place mentioned by Professor Dawkins, where the Permians had been recently discovered.

THE MEASUREMENT OF AIR CURRENTS IN MINES.

Mr. THOMPSON gave a *resumé* of his paper read at the last meeting upon this subject, the discussion on which had been postponed. [See Part 2, Vol. xvii.]

Mr. DICKINSON said he supposed that the writer of the paper, when he spoke of Robinson's anemometer as being "the only one in use," meant to say for meteorological purposes, and not for use in mines, because to his (Mr. Dickinson's) knowledge, only one such anemometer was in use in this County, and that was at Mr. Herbert Fletcher's Ladyshore Colliery. The anemometers in use at collieries were of various kinds, but he was not aware that he had any addition to make to what he had already, in his Paper on Measuring Air in Mines, laid before the

Society upon this subject. He might ask Mr. Thompson in what respect his register differed from that proposed by Mr. Hall some time ago—that was, by sound brought into the office; or from that recommended by the late Mr. Peace. Both of them were self-indicating anemometers.

Mr. THOMPSON said he had not had an opportunity of seeing the instrument introduced by Mr. Hall, but if it embraced the principle of the telephone the question of expense would be some difficulty in the way of its general adoption. Mr. Peace's instrument was no doubt very ingenious, but it depended, in its action, upon the cone, and this cone hanging in the shaft, became loaded with the dust and dirt that fell down the pit, and caused it to indicate abnormally. In addition to that, the rushpast of the cage, each time it passed up or down, produced a sort of hurricane, and caused the needle indicator to dance about; and he thought the instrument frequently sustained damage in that way. Speaking of "the only anemometer now in use," what he meant was an anemometer which is an acknowledged register of the velocity of the wind. The law had been admitted by everybody, since Dr. Robinson's days, of the proportion which the velocity of the wind bears to the velocity of the cups, and he thought the reality of the investigations justified him in speaking of the cups as a reliable scientific apparatus.

Mr. SEDDON said he formed the idea, from Mr. Thompson's paper, that the instrument described was a very ingenious combination of the principle of electricity, as illustrated by the telephone, and of the meteorological system of observing the velocity of the wind, and from what he had seen of the two, separately, and also from his knowledge of pits, he had come to the conclusion that it was practicable, and desirable, as far as large mines are concerned, that Mr. Thompson's idea should be thoroughly tested. He

thought he was right in saying that it had not yet been brought into practice, but he gathered from what Mr. Thompson said at Wigan, that it shortly would be, and until that time arrived it would remain an undeveloped theory, but capable of practical application. The difficulty he saw, himself, in connection with it, was that in no matter how isolated and undisturbed a part of the mine it might be placed, it would still, in a certain degree, be liable to gather dust. This might be even where the atmosphere was generally exceptionally fine. He assumed, the great object would be to place it in the return air-way; but he could see that, even in a quiet dumb drift, which was a favourable place for observing its action, it would be liable to gather dust, which might vary its motion and necessitate frequent cleaning, and underground workers were hardly the sort of men in whose charge such delicate instruments could be placed for adjustment. That was the difficulty he saw, but Mr. Thompson's ingenuity might be able to overcome it. It was also open to question whether the fact of being able to take observations on the surface by the aid of the telephone, would not induce idleness on the part of those who should attend to that duty in the mine rather than on the surface.

Mr. WILD said he would like to hear the result of the trial at Mr. Herbert Fletcher's colliery. He could form no opinion of the possible utility of the telephonic arrangement. They had had in use at the Bardsley colliery, many years, an apparatus consisting of a light float-board a foot square, hung in the return air-way, and the register was actuated by a string from the float going over a small pulley, with a slide indicating the number of feet passing per minute. This arrangement seemed to have acted very well. Occasionally it would collect a little dust from being in the return air way; but it was the thinnest film possible. It was sufficiently accurate as a rule for practical purposes.

Mr. SEDDON said that since hearing Mr. Thompson's paper read, he had been so much struck with it that on visiting Southport a week or two ago, he took the opportunity of observing Robinson's cups, attached to an anemometer given by Mr. Fernley in Hesketh Park. He asked an attendant whether oxydisation had been noticed on the mechanism, to such a degree as to interfere with the motion of the cups, and was informed that in certain states of the weather, a slight disarrangement took place not so much from dust—that was, dust, in the ordinary acceptation of the term—as from particles of fine sand, and oxydisation caused by the salt air from the sea. If these effects were produced on the coast, he was sure they would also be produced in the return air of a mine.

Mr. W. EVANS said that a few months ago he had made experiments with a Byrom anemometer in a similar manner to that proposed by Mr. Thompson. He thought it was possible that the system might be so arranged with governors to register a partial stoppage of air. There was the objection to the system which would arise from the action of the dust in the mine, as the slightest film of dust on the contact maker would prevent the operation of the electric current.

Mr. MARTIN considered that if the instruments were found to work satisfactorily and were distributed in various parts of the mine, near the working places, they would be a great advantage, as it is more important to know the quantity of air in the far end workings than to know what is going down the shaft. The quantity of air going down might be very large, but it was occasionally not satisfactorily distributed through the workings which are at considerable distances from the shafts.

Mr. THOMPSON, in replying, said that the difficulty with regard to dust had been got over by enclosing the entire

mechanism in a dust-proof box, which could be air-tight if necessary. If not in use now, Peace's anemometer had been considerably used at the Haigh Collieries, when those collieries were the property of the Earl of Crawford. The question of using governors was one which had occurred to his mind, but he could not see as yet how governors could be practically employed. It would be very important if they could make an instrument which would give an alarm when it was running below what was the desired speed. If, however, governors were attached to the mechanism of the cups some resistance would be occasioned, and how far this would interfere with the proper working of the apparatus he was not at present in a position to say. Whether it was fixed in the dumb drift or any other part of the mine would matter nothing if the apparatus was dust proof.

Mr. SEDDON: The statement that the apparatus is to be enclosed in a dust-proof box disposes of my objection.

ON THE OCCURRENCE OF MANGANESE AND HÆMATITE AT NANT UCHAF, NEAR ABERGELE, DENBIGHSHIRE, IN OLD RED SANDSTONE OR CARBONIFEROUS BASEMENTS BEDS.

By C. E. DERANCE, Assoc.INST.C.E., F.G.S., F.R.G.S.,
Of the Geological Survey of England and Wales.

The Geological Survey Map of Flintshire and Denbighshire, shows that the base of the Carboniferous Limestone, does not always rest directly upon the various underlying beds of Silurian age, but is supported by a deposit of Old Red age, which locally increases to a considerable thickness, is occasionally absent altogether. The detailed examination that my friend, Mr. G. H. Morton, F.G.S., has subjected the Flintshire Carboniferous Limestone, has clearly established

that this formation is composed of several distinct beds, indicating in some degree changes in the condition of the sea-bed, expressed by a fauna, containing species peculiar to each horizon, and he has established that in certain portions of the area, the lower beds were never deposited at all, and the middle beds rest either directly on the Silurians, or upon the Old Red, but this formation is also present on the base of the lowest beds known, consequently it may be regarded as the *local base* of the Carboniferous series, and occasionally is the equivalent in time, of true beds of Carboniferous Limestone, in other portions of the area. These Carboniferous basement-beds resemble the true Old Red of South Wales, in consisting of alternations of shale, and shingle beds, with occasional lenticular masses of earthy limestones, resembling the "corn stones" of South Wales. Both shale and shingle beds are stained a deep red by the presence of iron, and all water issuing from them is distinctly ferruginous.

I have lately had the opportunity of examining the base of the Carboniferous series in the neighbourhood of Sedbergh, and have followed the Old Red, or "Basement beds" for many miles along the Craven fault. The character of the beds is precisely like that exhibited by the Denbighshire and Flintshire rocks of this age, with a much increased thickness in Yorkshire, wherewith not only similar iron-stained shale, and iron-cemented pebble beds occur, but the included fragments appear to have had a common origin, a pale green rock occasionally containing Ludlow fossils being especially noticeable, and as in Wales, the limestones are conformable to the basement beds, but the latter are unconformable to the underlying Silurians. This is also the case in the so-called Old Red beds, still further north, forming the base of the magnificent pile of carboniferous rocks, forming the Cross Fell range, in the Vale of Eden,

where the same ironstained conditions are observable, and hæmatite iron-ore has been worked to a limited extent.

Considering these facts as a whole, the questions arise, What relation in age of deposition, has the iron-ore occurring at the bottom of the Carboniferous Limestone to that occurring on the top of that formation in the Furness district, in South Wales and Somersetshire; and, is the iron-ore occurring disseminated through the Old Red or Basement beds a contemporaneous deposit, or is it due to subsequent infiltration?

To these questions, an answer is, I think, in some degree furnished by a very interesting section that has been opened out by the Abergele Hæmatite Co., at Nant Uchaf in Denbighshire, at the back of the range of Carboniferous Limestone hills which run parallel to the coast between Abergele and Old Colwyn. The mine is situated on the lowest beds of the Old Red, or basement beds of the Carboniferous, and the depth of the workings is limited by the presence of the Denbigh Flags of Silurian age, the dip of of these beds is followed seawards as far as the boundary of the mining property will allow. Immediately below the shaft to the south is the outcrop of the Silurian rocks, a little way up the hill northwards is the base of the Carboniferous Limestone, which probably attains a thickness of 1,000 feet, the hill not being high enough to bring in the highest beds. The total thickness of the Old Red is about 300 feet, of which the operations of the mine have proved the lower 150 feet. Good examples of the corn stones have been passed through in the Engine shaft, and masses of conglomerate occur associated with thick deposits of Red Hæmatite iron-ore, and Manganese which appear to have been deposited by water percolating from above, and in many cases to have entirely replaced the limestone originally occupying the site, solid masses of

Manganese and Hæmatite following the dip of the strata, with all the regularity of the bedded rocks, which they have replaced. These ore-deposits vary in thickness from six to twenty feet, and are overlaid by a thick-bedded gritty limestone, beneath the ore deposit is a thin bed of dark red sandstone lying immediately on the Silurian flag floor the surface of which is extremely irregular and appears to be waterworn, channels filled with ore-deposit, being separated by ridges of the Denbighshire grit, over which the thickness of the ore is much reduced.

The No. 1 shaft is nearest the outcrop of the "Basement Beds," it is 400 feet above Ordnance datum, and is 15 yards in depth, it is carried entirely through the basement beds, and is over the Silurian rocks which, I am informed, has been bored into to a depth of 15 yards and no ore discovered. The Red Hæmatite was worked here some time ago, and a considerable quantity obtained following the dip to the No. 2, or engine shaft, which is 40 yards in depth, and 80 yards distant from No. 1, measured on the surface. Nothing was known at the time of the existence of Manganese, nor was its presence ascertained when the present management first commenced, its hard and compact character recommending itself as a suitable road material, and a layer six inches deep of it was spread over the lane connecting the mine with the high-road, shortly after this the attention of Major Wright, of Bagillt and Rhyl, was drawn to the material and he found it on analysis to be a Manganese ore, containing 60 °/₀ of metallic Manganese and a small proportion of Hæmatite, the thickness on an average is about 3 feet, but it varies from 7 inches to 7 feet in thickness, it rests upon the Hæmatite which decreases in thickness as the Manganese increases, the united ore- deposit remaining about the same, the maximum being 17 feet and the minimum 6 feet.

When I examined the district in June of the present year,

I found that deserted shafts had been sunk to the iron ore higher up on the hill, by previous explorers, and it struck me that here also the manganese ore, probably formed the roof, and had been left through ignorance of its character, this has, I am informed proved to be the case. The evidence afforded by the two mines, proved the existence of distinct furrows in the Silurian floor, which have been filled up with ore, hæmatite below and manganese above, deposited from the interpolating through the upper portion of the basements beds.

A careful series of investigations have recently been carried out by my friend Mr. E. Wethered, F.G.S., F.C.S., into the quantity of water different rocks are capable of holding when saturated, from which it appears that a cubic foot of Carboniferous Limestone is capable of only absorbing 0·043 of a gallon of water, or 3½ million gallons to a square mile 3 feet thick, while the millstone grit of the Bristol coal-field absorbs 0·081 gallons of water, or 6 million gallons per square mile, and the millstone grit of the Forest of Dean absorbs no less than 0·854 of a gallon of water to a cubic foot, or 71 million gallons to a square mile, and he points out the direct relation of this degree of porosity has to the presence and richness of the hæmatite contained in the workable beds of hæmatite occurring in the impermeable grit of the Bristol district, while they are extensive and important in South Wales, and the Forest of Dean, where the grit is porous, and admits the ready passage of water, and he agrees with Mr. Etheridge that the hæmatite is derived from the iron by percolation of water, which in the case of the Carboniferous Limestone, from its impermeable character, must be along lines of joints and fissures only these being traversed by water charged with carbonate of lime and iron. Complete saturation taking place the excess of carbonic acid was given off, and carbonate of lime separ-

ated in the crystalline state, and later peroxide of iron was thrown down, when oxidation was possible.

The chemical process suggested applies to the remarkable deposit of manganese and hæmatite at Abergele, but not as to the geological age of the infilling, or the source from which the ores were derived. There is every reason to believe that the manganese and hæmatite deposit continues northward under the hills of Carboniferous Limestone, and possibly under the sea itself, and if the ores were derived from Triassic rocks since denuded, it follows that the water percolating through them, and abstracting the ores contained in them, must have percolated through the entire thickness of the Mountain Limestone, a depth of not less than 1,200 feet, then through the alternations of shaly beds and conglomeration forming the basement beds, which is in the highest degree unlikely, as ores so carried would be deposited in surface fissures and caverns in the after beds, as is the case with the hæmatite deposits of South Wales and Somerset, derived from percolation from the Triassic rocks and of the Furness district, derived from percolation from the Permian rocks, which for practical purposes may be regarded together as post-carboniferous. Those occurring in the Basement Beds would appear to be derived from percolation through the beds themselves, and the subsequent segregation of the metal at the bottom of the deposit, where the further descent of the water was cut off by the impermeable floor of Silurian flag, in this case it would appear that the introduction of the manganese and iron was contemporaneous, but that its concentration was subsequent to its deposition, the process having gone on by a species of pseudomorphism, the limestone being gradually replaced by the metalliferous deposits. If this view be established, there are two sources of supply of hæmatite occurring in the Carboniferous Limestone and its Basement Beds—one

coming in from beds above the Carboniferous Limestone, and deposited in fissures in its upper beds, the other derived from the upper portion of the Basement Beds and deposited in flats, and beds, immediately above the junction of the carboniferous series, with the Silurian floor beneath.

In connection with this subject, it is worthy of note that in parts of the Lake District of Cumberland and Westmoreland, veins and fissures filled with hæmatite occur in situations where there is strong reason to believe the Old Red, or Basement conglomerate, was once present. North of Ulleswater and elsewhere in the Lake District some fragments of this formation still remain, and a careful study of the surface configuration of the ground leads to the conclusion that many upland cols and valleys belong to an ancient system of drainage, since destroyed by denudation, and that the Basement conglomerate still remaining in some of them occupy hollows cut in the Silurian rocks in pre-carboniferous times, and there is much to support the view, that these ancient valleys were once all filled with the Old Red, or Basement beds, and that subsequent faulting in the Silurian floor beneath, allowed the introduction of Iron Ore into the fissures laid open by the faulting until filled up by percolation of water from above.

To sum up the facts noted, (1) it would appear probable that the discovery of rich deposits of manganese near Abergele may lead to its being found in some of the very numerous localities along the Welsh border when the same conditions prevail.

2. That the source of this ore deposit was the Basement beds themselves, the metal being concentrated by percolation of water downwards until arrested by the impermeable floor beneath.

3. That the hæmatite of the Lower Silurian rocks of the Lake District have had a similar origin.

4. That the iron ore lying near the surface of the carboniferous limestone in South Wales, Somerset, and the Furness districts have a distinct origin, and are derived, as suggested, from the Permian and Trias red rock.

5. That the cobalt associated with limonite, of Cwm, near Rhyl, described by my former colleague, Dr. Foster, H.M. Inspector of Mines, belongs to the last set of conditions.

Mr. STIRRUP said that he had been greatly interested in this paper, because it had always been a puzzle to know whence the great deposits of hæmatite and manganese had been derived. It should be understood, however, that those ores might have been formed almost at any period—that they did not belong to any one age in particular. Only recently he read an account of some iron ores being found in Spain—they were called bog iron ores—which contained leaves of trees and plants which certainly were of late tertiary age. The opinion which Mr. De Rance had given was one which seemed to bear the impress of truth. He (Mr. Stirrup) had always understood that the colour of the red rocks—both of the old red and the later Triassic rocks—was derived from iron oxide. The present thickness of those beds gave them no idea of what might have been their thickness originally; and it was from those vaster deposits of red rock that possibly the remarkable deposits of iron ore, now so valuable, had been derived.

Mr. DICKINSON said the formation and filling up of mineral veins was a wide subject—one which, of itself, would occupy a large volume. The experiments of Mr. R. Vere Fox in Cornwall, and Mr. John Leithart, of Alston, Cumberland, were a study in themselves. The conclusion which both those gentlemen arrived at was that the formation was due to a slow and gradual process of transmutation, or transposition. Mr. Leithart, from his experiments, showed that

there was this change going on in the mines, and that crystals were gradally being formed—that it was a slow process and not the result of any sudden volcanic eruption, as had been supposed. In Kirkcudbrightshire a large portion of the hæmatite that existed was found in the red veins; and in the Forest of Dean the hæmatite lay below the main beds of limestone, but in a coarse limestone locality called creese stone. Limestone seemed to have a great affinity for iron; many of the principal deposits were in it; and many beds were changed from limestone actually into iron stone in different parts of the district. The subject, however, was a wide one, and he could not think of entering into it in relation only to one small district.

In reply to Mr. Burnett,

Mr. De Rance said that the iron ores in the Furness district appeared to belong to a different set of conditions from those which occurred in the Silurians of the Lake district. The two districts happened to be near each other, but the method of deposition appeared to have been dissimilar. With regard to Mr. Dickinson's remarks respecting the affinity of limestone for iron, it occurred to him that limestone was especially liable to have open joints and fissures. Careful experiments made lately by Mr. Wethered, in connection with the Underground Water Committee—of which he (Mr. De Rance) was Secretary—had clearly shown that limestone was one of the rocks which contained and absorbed the least amount of water; whereas the sandstones contained more, and the open sandstones still more. They could readily understand that water travelling through the mountain limestone could not pass through the body of rock, because it contained only ·043 of a gallon per cubic foot—a most homœpathic quantity—but they knew from experience in Derbyshire and elsewhere that there were underground streams in the carboniferous limestone,

and that the water did not pass through the rock but through the fissures in the rock; and when water, travelling through the fissures, could no longer find an outlet, matter either in mechanical suspension or chemical solution was thrown down into the fissure. It was not that the limestone had affinity for iron, but that limestone was the best jointed rock with which they were acquainted.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XVII. SESSION 1882-83.

At the ORDINARY MEETING of the Members of the Society, held on Friday, the 5th day of January, 1883, in the Council Chamber, Municipal Buildings, Wigan;

J. AITKEN, Esq., J.P., President,
in the Chair.

The following are the recent additions to the Library:—

Broeck, E. V.: Four Pamphlets by E. V. Broeck.—*From the Author.* Cornwall: Catalogue of Library of the Royal Geological Society of, 1882.—*From the Society.* De Rance, C. E.: Eighth Report to British Association on Underground Water Supply.—*From the Author.* Geological Magazine: Nos. 220-23; 1882-3.—*Purchased.* Geological Record for 1878.—*Purchased.* Hertfordshire Natural History and Field Club: Transactions; Part 2, Vol. II.—*From the Council.* Institution of Mechanical Engineers: Proceedings; No. 3; 1882.—*From the Council.* Liverpool Geological Association: Transactions; Vol. II.; Session 1881-82; Annual Report, 1882.—*From the Society.* London Geological Society: Quarterly Journal; No. 152, Vol. XXXVIII.; List of Fellows (November, 1882).—*From the Society.* London Geologists' Association: Proceedings; No. 6, Vol. VII.—*From the Council.* London: Royal Institution: Proceedings; Nos. 73-74, Vol. IX., Parts 4-5.—*From the Society.* Manchester: Victoria University: Calendar; Session 1882-3.—*From the Council.* Manchester Field Naturalists' Society: Report for 1881-2.—*From the Council.* Midland Institute of Engineers: Transactions; Parts 58-61-62, Vol. VIII.; and Revised Rules.—*From the Council.* Mining Institute of Scotland: Transactions; Parts 6-18, Vol. IV.; 1881-2.—*From the Council.* North of England Institute of Engineers: Transactions; Part 5, Vol. XXXI.; Parts 1-2, Vol. XXXII.—*From the Institute.* Salford Museum, Library, and Parks: Annual Report, 1881-2. South Wales Institute of Engineers: Proceedings; Part 2, Vol. XIII.—*From the Institute.* Hayden, F. V.: U.S. Geological Survey of the Territories; Bulletin; Nos. 1-3, Vol. VI. New York: American Museum of Natural History: Bulletin, Vol. I., Parts 2-3; 13th Annual Report (February, 1882).—*From the Committee.* Smithsonian Institution, U.S.A.: List of Foreign Correspondents (corrected to 1882).—*From the Institution.*

Australia: Annual Report of the Department of Mines, 1880-81; Journal of the Royal Society of New South Wales, 1881; Minerals of New South Wales. New South Wales: Brief Statistics and Descriptive Account of; by Thomas Richards; 1882.—*From the Royal Society, N.S.W.* Quarterly Reports of the Mining Surveyors and Registrars; Victoria; June, 1882.—*From the Secretary of State, Victoria.* Foreign: Académie Impèriale des Sciences, St. Pétersburg: Mémoires; VIIe Série; Tome XXX., Bulletin; Nos. 4, 6, and 8.—*From the Académie.* Buenos Ayres: Officina Nacional de Estadistica Commercial de la República Argentina; Continued Statistics, 1882.—*From the Government.* R. Accademia dei Lincei: Transunti; Vol. VII., Fas. 1°.—*From the Academy.* Deutsche Geologische Gesellschaft-Zeitschrift: Heften 2-3, Band XXXIV.—*From the Society.* Società Toscana de Scienze Naturali: Processi; Vol. III.—*From the Society.* Société Royale Malacologique de Belgique: Annales; Tome XIV.-XVI.—*From the Society.*

The HON. SECRETARY took the opportunity of urging upon Members the desirability of there being a more general response to the demand for suitable papers to be read at the meetings. On this occasion, Mr. H. Hall had kindly undertaken, at very short notice, to provide one.

NEW MEMBERS.

The following gentlemen were balloted for, and duly elected Ordinary Members of the Society:—

Mr. Thomas Greensmith, Manager, Moston Colliery, near Manchester.

Mr. William Penn Mather, Iron Works, Salford.

A NEW ANEMOMETER.

"Description of a new Anemometer, invented by Monsieur Bourdon," communicated by Mr. Henry Hall, H.M. Inspector of Mines.

Mr. HALL remarked that M. Bourdon was the inventor of steam and pressure guages of every description, and that although now a very old man, he still seemed to be working at new inventions. The paper describes the anemometer as nearly as possible in M. Bourdon's own words.

THE MULTIPLYING ANEMOMETER FOR MEASURING THE SPEED OF THE WIND IN THE GALLERIES OF MINES.

Taking for the starting point of my inquiries the well-known property which the converging and diverging tube of Venturi possesses of producing at the point of junction of the truncated summits of the two cones, a degree of vacuum which is measured by a column of water higher than the generating current which enters it, I have thought that by graduating in order several tubes of similar forms with decreasing diameters, I should obtain at the last step of the apparatus thus made a degree of vacuum much greater than that which could be obtained with a single tube.

Experience has confirmed my surmises, and it is upon this principle that I have constructed the "Multiplying Anemometer."

Arrangement and Respective Proportions of the Tubes composing the Anemometer.

Where it is required to measure the movements of air where the speed is above three metres a second (about 10 feet), the number of tubes which compose the instrument may be limited to two, and of the dimensions indicated upon Fig. 2.

The interior tube ought to be placed exactly at the centre of the exterior tube, and there be secured by at least three little rivetted crossbars at equal distances from each other.

The two truncated cones forming the interior tube ought to have between their small bases a circular space free of about six-tenths millimetre, surrounded by a copper collar, serving to unite the two cones together, and to establish by means of a little pipe or tube a communication between the interior of the tube and the manometer indicating the degree of vacuum.

Afterwards fix upon the body of the instrument a pipe of copper of small diameter (4 to 5 millimetres), bent according to the form shown on Fig. 4.

One of its extremities presents itself at the centre of the egress orifice of the large tube, and the other reaches to the second arm of the manometer. By this means is established the equilibrium of pressure necessary for the correctness of the instrument.

Fig. 3 represents an anemometer with three tubes fixed, according to the arrangement shown for that of two tubes.

Its sensibility, or in other words the height to which it can raise the column of water in the manometer P N, is quadruple of that obtained with an anemometer of two tubes, and it is most suitable for measuring very feeble currents, and combined with a registering apparatus with clock movements, it traces the curve of the variation of the speed of the current with much more exactness than the anemometer with only two tubes, and is also suited very well for putting into play electric bells employed as warnings of insufficiency or excess of ventilation.

Although the figures here annexed only represent instruments composed of two and three tubes, it is understood of course that the number of them can be increased, and the height of the water in the manometer will be proportionately increased, but constituted as shown on the sketch. The instrument satisfies every condition required for the measurement of the speed of the wind, and to that is added the advantage of its being easily carried and fixed in the galleries of mines.

Mode of Working of the Multiplying Anemometer.

At first sight it is difficult to understand the cause which in this system of anemometer produces at the small section of the last tube a negative pressure, which increases very rapidly in amount as the number of the tubes which compose the instrument are increased.

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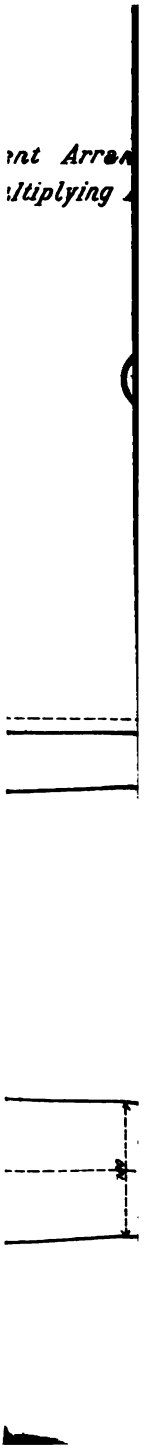

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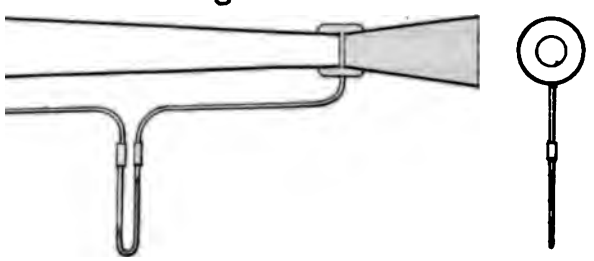
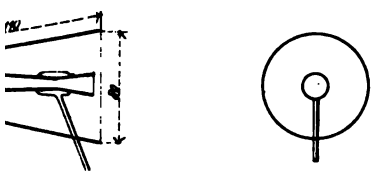
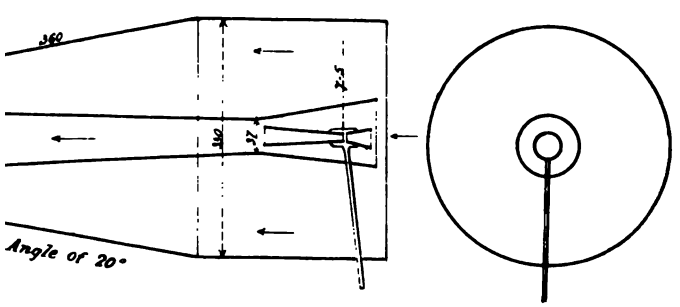
Fig. 4







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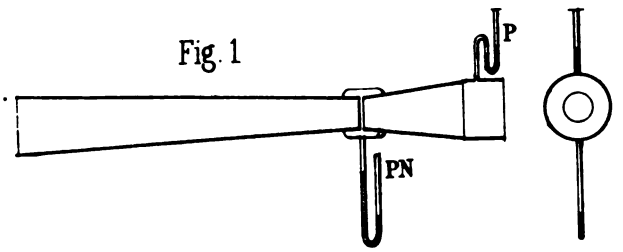


Fig. 2

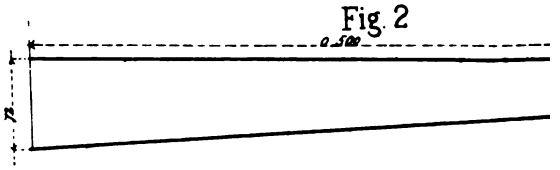
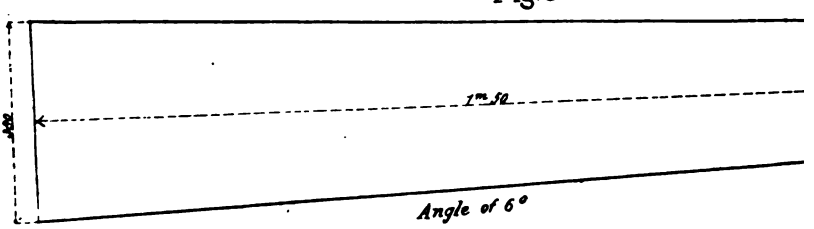


Fig. 3



In order to explain this, and to make it easily understood, it will be well only to consider at first what is the effect produced by a single tube, to which is fixed on the side of the entrance of the wind a manometer P (see Fig. 1), serving to measure the pressure due to the propulsive action of the ventilator; then at the small section of the diverging cone another manometer P N, indicating the negative pressure engendered at that point by the contraction of the fluid medium.

When the ventilator puts the air into motion the column of water will be seen to raise itself in the manometer P N to a height six times greater than that indicated by P, and which indicates the pressure due to the speed of the current.

It follows, then, that with a single tube one can increase in the ratio of 1:6 the height of the column of water which measures not directly, as with the tube of Pitot, but by difference, the pressure and eventually the speed of the wind circulating in a gallery of a mine.

This kind of pneumatic action of the tube with the double cones being well understood, it will be easy to see how a second and a third tube of the same form, but of decreasing dimensions, possesses the property of increasing at each step the degree of vacuum produced by the first. In fact, if into the interior of the first tube, just at the point where the column of air reaches its maximum contraction, one introduces the diverging extremity of a second tube of the same form, but small enough, so that it only occupies the central part of that which surrounds it, the flow of air will increase in this second tube, not only on account of the propulsive action by which the whole of the current air is animated, but still more through the influence of the atmospheric pressure, which presses with all its weight upon the entrance orifice, whilst the outward orifice is plunged into a medium of air already sensibly rarified.

The comparison between the heights of the water in the manometer P and of that in P N, which was 1:6 with a

single tube, will be 1:20 with an instrument of two tubes, and if a third is added and fixed in the same manner as the second, but of smaller dimensions, then the indication will be quadrupled—that is to say, that the column of water kept in equilibrium by the excess of the pressure of the atmosphere over that existing in the interior of the third tube will be in the proportion of 1:80, or 80 times higher than that obtained with the single tube of Pitot.

It would seem natural to suppose that the height of the water being as 1:6 with a single tube, it ought to be multiplied by 6 for the second tube, but that is impossible, for this reason: the passage of the air current is not entirely free, as with a single tube. That which comes afterwards and occupies the central part retards the passage of the current, from which results a lessening of its power.

The advantages which are peculiar to this system of anemometer are easy to understand. Its extremely simple construction necessitates no moveable part, and to this may be added the excellent property of increasing considerably the height of the manometrical column, generated by the speed of the current.

It may be said that it furnishes a new means of increasing, like that of the microscope, but very different in its nature, and can, like it, render very useful services for purposes such as the measurement of the air in mines.

Determination of the Speed of the Wind with the Anemometer of two Tubes.

In order to measure the speed of the wind by this system of anemometer, the most simple method consists in putting into communication, by means of a pipe of small diameter, the last conical tube of the apparatus with a manometer vertical water tube, or with a manometer with a tube inclined, which by reason of the length of its divisions renders easy the reading of very small variations of the height of the column of water. The instrument must be placed upon

a support 3 or 4 feet high—that is, about half the height of the gallery, taking care that the arrow heads traced upon the big tube are turned to follow the direction of the current.

Under the influence of the speed of the current, the water will rise in the tube of the manometer P N, and after some moments will maintain itself at an average height.

With an anemometer of three tubes you will proceed in precisely the same way, the difference in the result being that the water is raised four times higher than is the case with the anemometer of two tubes.

Vilesses du vent et dépressions observées à chacun des trois tubes.

VITESSE du vent et mètres par seconde $V = \sqrt{2gH}$.	PRESSION en millimètres d'eau contre un tube ouvert $H = \frac{V^2}{2g}$	DÉPRESSION EN MILLIMETRES D'EAU. au premier tube.	au deuxième tube.	au troisième tube.
mm.	mm.	mm.	mm.	mm.
1·10	0·1	0·3	0·9	4
1·50	0·2	0·6	1·8	6
1·90	0·3	0·9	3·6	11
2·30	0·4	1·3	4·6	17
2·60	0·5	1·7	6·0	21
3·00	0·6	2·1	6·5	28
3·20	0·7	2·5	9·2	35
3·50	0·8	3.0	10·8	44
3·70	0·9	3·5	14·0	56
3·90	1·0	4·0	16·0	65
5·70	2·0	8·0	32·0	135
6·90	3·0	13·0	52·0	210
8·00	4·0	17·0	70·0	290
9·00	5·0	21·0	87·0	370
9·80	6·0	26·0	110·0	450
10·50	7·0	30·0	126·0	530
11·30	8·0	35·0	149·0	620
12·00	9·0	40·0	168·0	710
12·70	10·0	45·0	190·0	800

Mr. BRYHAM said the new anemometer seemed to him to be an instrument that might be used with very great advantage.

The PRESIDENT expressed the opinion that this was a very important application or extension of a principle which was already known. The invention seemed very valuable on the ground of its simplicity as regards construction of the instrument. Moreover, the cost involved in its application would not be great. He would be glad if Mr. Hall would state if the anemometer in question had been applied practically in any mine, or was its invention so recent that there had not as yet been any attempt to apply it practically.

Mr. HALL said that, so far as he knew, it had only been used experimentally. The attention of the French Commissioners on Fire Damp had been called to it, and they made some experiments, and reported that they found that the anemometer might be used with advantage to measure velocities, where velocity was about 13 feet per second, but that where more than three tubes were needed to measure velocities they considered that there might be a danger of the smallest tube getting chocked up with coal dust.

The PRESIDENT: What is the diameter of the smallest point of the smallest tube?

Mr. HALL: Five-sixteenths of an inch only, but with a three-tubed instrument the diameter might be much larger by enlarging the size of the outer tubes. But another difficulty is arrived at then, viz., that the machine becomes so large as to obstruct, in some degree, but not to the extent that it would at first sight appear to do, because the air is travelling through it all the time.

The discussion was adjourned, and at the close of the meeting a vote of thanks was passed to the Mayor of Wigan for allowing the use of the Council Chamber.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XVII. SESSION 1882-83.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 6th day of February, 1883, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., J.P., President,
in the Chair.

THE PERMIAN ROCKS, SOUTH OF MANCHESTER.

Professor BOYD DAWKINS called attention to Mr. Brockbank's letter in the *Manchester Guardian* of to-day (6th February) announcing the discovery of Permian strata in Slade Lane. The strata in question in Slade Lane belong, as Professor Dawkins pointed out to this Society on December 5th, 1882, (see Transactions, Part III.,) to the upper coal measures, with the *spirorbis* limestone, which has long been worked at Ardwick, and not to the Permian formation. The Permian rocks, however, have been proved to exist, as was then pointed out, in Mauldeth Road, Withington, and were first discovered by Mr. Arthur Dendy as far back as the 23rd of September, 1882.

NOTES ON SAFETY LAMPS.

By Mr. Joseph Dickinson, F.G.S.

In bringing Mr. Green's paper before you I wish to say a few words in order to make it plain to all as to what the improvements consist of, and the need of such improvements.

The first safety lamp is, I think, admitted to have been invented by Dr. Clanny; but it depended upon the supply of air having either to be carried with it or to be conveyed in a pipe to it, and not upon the atmosphere of the place in which it had to burn.

The testing for firedamp had then to depend upon thin dip candles with small wicks, or a small part separated from a larger wick; and the sparks from flint and steel which were sometimes struck by the revolving wheel of what was called a steel mill.

The grand invention of the Davy lamp, and the, perhaps, less important invention of the Stephenson, date but from 1815.

Lamps still bear the name of all these first three inventors; that of Davy being still almost identically the same as when originally produced, the others having now but little resemblance to the originals.

Mr. John Buddle, the eminent Viewer at Wallsend colliery, first introduced the Davy; and Mr. Nicholas Wood, as a young man, was one of the assistants who introduced the Stephenson, under the Brandlings. It was my good fortune to know both of these gentlemen, and to the former, in conjunction with Mr. Sopwith, I was indebted for my start in life after my apprenticeship. I have many times talked with the Overmen who acted under Mr. Buddle, and have had narrated the jealousies which existed respecting the two inventions.

Both lamps were received at first with distrust, but the Davy soon became so popular that, with the sluggish ventilation and impurity of the mixture then in the mines, it came to be almost implicitly trusted, and was in some instances used for working with when burning firedamp filled the gauze, and with the gauze at dull red heat, requiring relays of cold lamps to be brought in to change the hot ones.

The records show that at times this procedure resulted in sad catastrophes.

Following upon this state of things ventilation began to be greatly improved, and is still continuing. But with this improved ventilation, the mixture, when not sufficiently diluted, has become more explosive.

The velocity of the currents have been also increased, so that lamps which stood the old requirements will not stand the new.

Many modifications have consequently been made in the lamps, to meet the altered circumstances, and to give better light. All of these, however, seem to depend upon the original principles of the Davy and Stephenson; that of the Clanny being still one basis on which irrespirable mixtures may be entered. And, with all the drawbacks, the Davy is still a great favourite, especially for testing,

Amongst the modified lamps is the Mueseler. It gives much more light than the Davy. It must be kept upright; and the leading principle of it is that it should go out in an explosive mixture. Like the Davy, the Mueseler in its turn came, in Belgium, to be rather blindly relied upon. The dimensions for the lamp published in the Belgian code of mining laws, in 1846, were found not to ensure safety, and they were altered in the supplement which was published in 1852. The changes then made apply chiefly to the size of the glass and of the chimney.

These sizes, and the construction of the lamp are shown in the accompanying sketch.

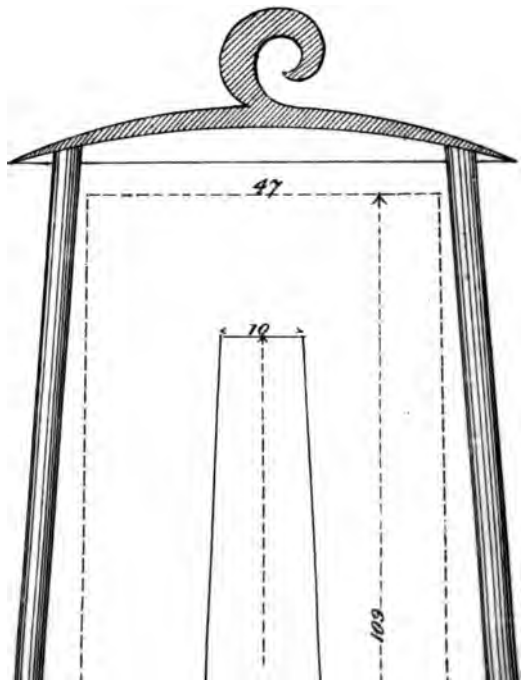
Even with the alterations then made it is now being found that the lamp is not always reliable, especially when an explosive current slants down upon it.

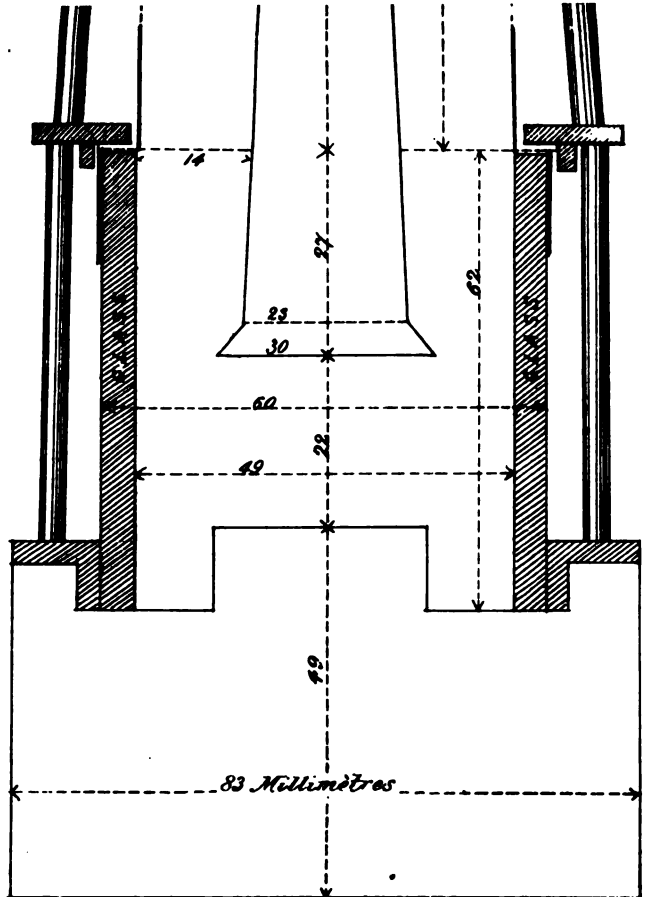
In the Celynen Colliery, of which Mr. Green is the manager, the mine makes gas freely, and as the levels there are not driven out to the extremeties before active working of the coal is commenced, the gas has to be dealt with in large quantities, which drain from numerous and large surfaces. Hence the necessity of a lamp on a reliable principle, and of a reliable means of testing that each lamp is secure.

During the course of these testings it has been found that in certain respects, the principle of the lamp is not secure. And it is the two improvements which have been made to rectify this that I have now to bring before you.

I have only to add that it was in August last, when I had occasion to visit the colliery, that the improvements and method of testing came under my notice; and I was so impressed with their importance that I asked Mr. Green to send an account of them to the Commission on Accidents in Mines, and to make them public—one result of which has been my obtaining for this Society the following brief but practical paper.

N° 1. Lampe Mueseler, *proprement dite,. Toile du cylindre et Toile du disque à 144 mailles au moins par centimètre carré, le fil ayant 1/5 de millimètre de diamètre au minimum (N° 18 jauge de Liége, N° 31 jauge Anglaise.)*




14
27
62
23
30
60
29
49
19
83 Millimètres

THE MUESELER SAFETY LAMP AND TESTING APPARATUS IN USE AT CELYNEN COLLIERY, MONMOUTHSHIRE.

By Mr. James S. Green.

(Communicated by Mr. Joseph Dickinson, F.G.S.)

The Mueseler Lamp was adopted at the Celynen Colliery in February, 1879. The workmen were unfavourably disposed with regard to using these lamps at first, but as they became aware of their greater safety as compared with the Clanny, valued them accordingly.

The following are the sizes, &c., of lamp as specified to the manufacturers: —

	Inches.
Glass.—Exterior diameter	2·36
Thickness	·21
Height including Socket.....	2·44
Chimney of Thin Iron.	
Interior diam. at top	·39
„ at base of bell mouth	1·18
Diam. at top of bell mouth	·98
Height above horizontal gauze or disc	3·54
Below ditto	1·06
Bell mouth widening at base....	·23

Distance from base of chimney to top of wick tube ·86 inches.

Each lamp is tested in a box (see Fig. 2) erected over counter in receiving room before it is handed to the workmen. Gas and air are turned in (see Fig. 1) at one end of the box; about half-a-dozen lamps being tested together. Safety shutters are fixed in roof of receiving house, and a

sliding door in wall separating the same from lamp house, so that accidents may be prevented when explosions occur.

It being found that under certain conditions gas continued to burn underneath the disc or horizontal gauze after the flame on wick discontinued burning (a thin streak of flame revolving around at the base of tube), a small projection of tin was affixed to the tube at A (see Fig. 4) which effectually prevented it. This improvement to the lamp, with the addition of a shield about 2in. in depth around bottom of top gauze and resting on the top ring over glass (see Fig. 3) renders the lamp unexplodable under all probable conditions.

When sudden outbursts of gas have taken place in this mine the safety and reliability of these lamps have been proved on two or three occasions.

Great care should be taken by users of Mueseler lamps that the tube should not be too long, or too large at the top, and that the horizontal gauze or disc is carefully fixed on the tube.

Persons are undoubtedly wrong who assert that the practice of testing safety lamps at Bank in our explosive mixture of gas and air is useless and misleading. Damaged lamps have inadvertently and purposely been exploded in the Testing Apparatus at this colliery.

ADDITIONAL PARTICULARS *re* TESTING APPARATUS AT CELYNEN COLLIERY.

Size of Fan, 1ft. 9in. diameter.....	5in. outlet.
No. of revolutions per min.	500.
Diam. of gas pipe	1¾ inches.
,, pipe for air and gas.....	4½ inches.
Length of ditto.....	12ft. 6 in.

TESTING BOX (inside measure):—

Length, 5ft. Height, 1ft. 2in. Breadth, 6 inches.

Upcast pipe (wood) 5in. × 7in.

The PRESIDENT inquired whether the disc described in the paper was a part of the original Mueseler invention, or an improvement upon it. Also whether the light given by the lamp was equal to that of the Davy lamp, or the others ordinarily in use in mines.

Mr. DICKINSON: These two additions made by Mr. Green make no difference whatever either in the construction of the lamp or in the light it gives.

Mr. WOODWARD: One point that Mr. Dickinson has brought forward has not occurred to me before—that is, that the Mueseler lamp, under certain circumstances, is not safe. I thought the Mueseler had always been put forward as a perfect lamp. I have, however, myself seen pretty much what Mr. Dickinson has described—that even after the flame has gone out in a Mueseler of a certain construction there has been a burning of gas below the horizontal gauze.

Mr. DICKINSON: The disc gauze.

Mr. WOODWARD: That is the bottom gauze. I would like to ask whether, in Mr. Green's improved lamp, the gauze is double or single, because in the new lamps—I had one brought to me the other day—I see they have put in a double gauze, slightly separated by a brass ring, which they say entirely prevents the gas within the lamp from burning after the flame of the lamp is extinguished.

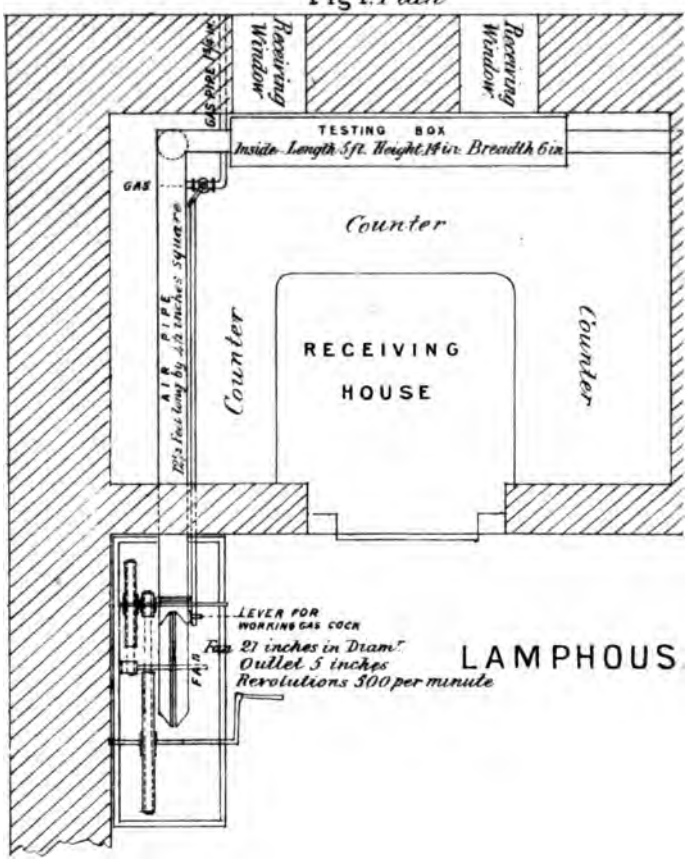
Mr. GEORGE WILD: With respect to the Mueseler lamp, as mention was made by Mr. Dickinson that a slant current of an explosive mixture might produce an accident, the lamp being liable to be exploded; but the shield which has been added by Mr. Green will doubtless be a great prevention of that. The chimney, however, is too short. As at present constructed a slant current can enter the chimney and cause the gas to explode from the light below. This, I think, might be prevented by lengthening the chimney, so as to exclude any slant current. It would be a great safeguard,

provided it did not materially affect the burning. I find it quite possible to explode it readily through the tube, and thence, with care (by keeping up the flame intermittently for a short time,) through to the outside of the gauze.

Mr. J. WILLIAMSON, of Hednesford, Stafford, said: I am here on the invitation of Mr. Dickinson, and have listened to the paper which he has read with much pleasure. I may say that I have had to do with safety lamps for many years, and I can remember the Davy and Stephenson lamps in very different forms from those of the present day. Some years ago, seeing the want of a better safety lamp than we had at that time, I made it a matter of study, went closely into it, and made many experiments, as in my humble way I thought it quite possible that something might be done to improve the lamps in common use. Five or six years ago I made a safety lamp—or rather, had one made—which I thought combined some improvements. My idea is that lamps should be of simple construction in few parts, and more care taken in the manufacture of safety lamps, and, at the same time, ought to give a better light than the lamps in use ordinarily. One objection I take to the Mueseler lamp is that it has only got a single glass. Anything happening to that glass would be fatal in an explosive mixture. In my lamp, if the Clanny glass, which is the outer glass, breaks, you still have a lamp as safe as the Clanny, or as safe as the Davy lamp. If the inner glass breaks you have simply a Clanny lamp. I have not seen the lamp that Mr. Dickinson has described, but I can see that Mr. Green's improvements are very important, and there is no doubt that, by going a little more deeply into the thing, a lamp can be made which will be almost as perfect as can be. I think, myself, that the Mueseler is a good lamp, but there has been one great objection raised to it—that is, if the Mueseler lamp happens

APPARATUS FOR TESTING S

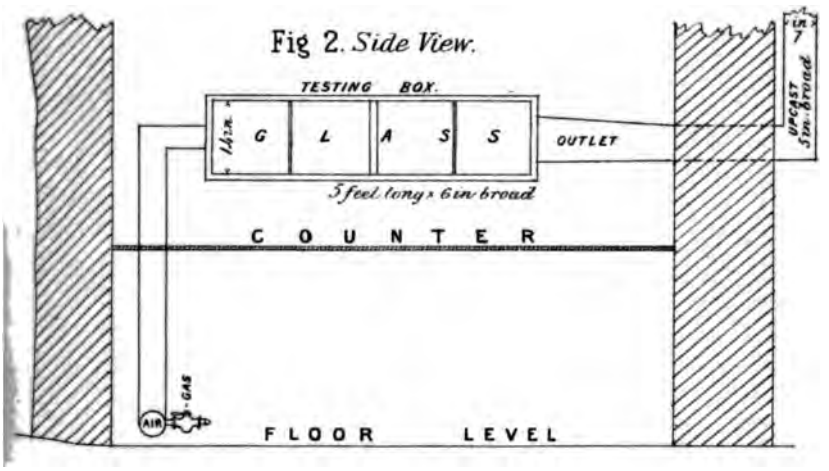
Fig 1. *Plan*



Trans. Man. Geo. Soc. Part V. Vol XVII

Illustrating Mr Green's Paper.

USED AT CELYNEN COLLIERY.



Trans. Man. Geo. Soc. Part V. Vol

Illustrating Mr. Green's Paper.

Mueseler Safety Lamp

with Shield about 2 inches in depth around bottom
top gauze and projection under the disc or horizontal
gauze as used at Celynen Colliery. Monmouthshire.

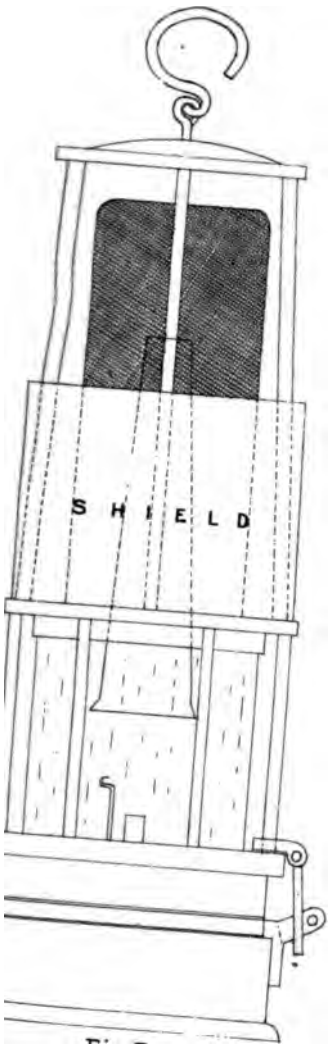


Fig. 3.
HALF SIZE.

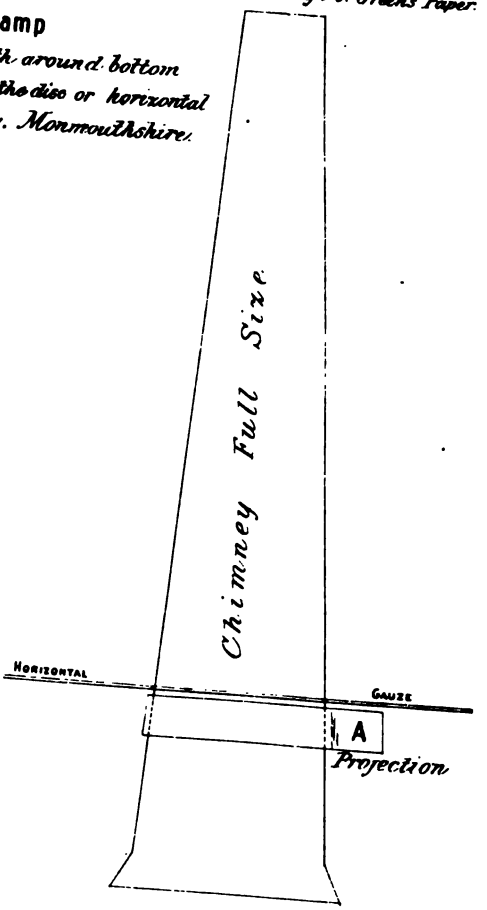


Fig 4

to get out of the perpendicular it extinguishes and you are at once put in the dark. But that, I think, has been obviated to some extent.

Mr. Dickinson: No.

Mr. Williamson: Well, that is an objection which a great many people raise to the lamp. In my mind, the Mueseler lamp is a good lamp; it is a simple lamp, and it is a lamp that a good many people like. We all have our likes and dislikes. Some of the best lamps we have at the present day are objected to by many. I know those who will persist in using the Davy lamp and nothing else, although that, as we all know, is far from being absolutely safe. It has been a good and useful lamp, and I do not know what we should have done without it, but I believe many explosions have been caused by the faulty construction of it and other kinds of lamps. I have seen lamps sent out that were not fit to go into any mine. I think every lamp maker ought to be made responsible for each safety lamp sent out.

Mr. Dickinson: I do not think I have anything to answer except the question put by Mr. Woodward about the double disc gauze. Such double gauze is not a part of the original invention of the Mueseler, but there is nothing to prevent its being added to it, if it does not make the lamp more liable to go out than at present. One other observation I should like to make in reply to Mr. Williamson. The Davy lamp has changed, perhaps, less than any other. The original Davy may still be seen in the Museum in Jermyn Street, London; and, except that the gauze is rather finer than the standard mesh at present, and the lamp somewhat smaller, it is identically the same as the Davy lamp now in use.

ON THE STRATA BETWEEN THE CARBONIFEROUS LIMESTONE AND THE COAL MEASURES IN DENBIGHSHIRE AND FLINTSHIRE.

By Mr. G. H. Morton, F.G.S.

The Carboniferous Limestone is well developed in Denbighshire and Flintshire. In several papers read before the British Association and the Liverpool Geological Society, I have shown that it may be divided into subdivisions presenting very distinct lithological characters, and that it varies in thickness from 100 to 1,200 feet. The lowest subdivision only occurs where the thickness is, or has been, considerable before denudation. The highest, the Upper Grey, extends over the greatest area, for it overlaps the underlying subdivisions. The successive subdivisions overlap each other in consequence of the inequalities of the Silurian rocks upon which the Limestone always rests. Near Llangollen, the overlap is so rapid that the thickness of the Limestone diminishes from 1,200 feet at Tynant to 300 feet at Fron, where the thickness has been still further reduced by denudation to 88 feet. The subdivisions adopted in my former papers on the Carboniferous Limestone, are the Lower Brown Limestone, Lower White Limestone, Upper White Limestone, and the Upper Grey Limestone.

Above the Limestone there is a series of sandstones and shales, varying in thickness from 648 feet on Cefn-y-Fedw, near Llangollen, to about 370 feet near Prestatyn, and being thicker and more fully exposed at the former than anywhere else, I have named the Cefn-y-Fedw Sandstone. The lowest beds of the formation are composed of hard white sandstone, containing great numbers of white quartz pebbles, while the highest beds are yellow sandstone, shale, and grit. At the east of Cefn-y-Fedw the highest subdivision has been named the Aqueduct Grit, for the

piers of the Aqueduct on the River Dee are built upon its exposed out-crop. Above the Aqueduct Grit the Coal-measures succeed, and the base seems always a thick series of black shales. At Australia, near Trevor Station, there is a large quarry in the Aqueduct Grit, and the Chwarle Coal, 1ft. 6in. to 2ft., rests upon it, but another bed called the Aqueduct Coal is about 59 feet higher up in the shale. At Tyfyn-uchaf, two miles to the north, the Aqueduct Grit is succeeded by 30 feet of shale and the Aqueduct Coal. In many other sections the Grit seems to be succeeded by a thick shale, without any bed of coal.

The whole of the subdivisions of both the Carboniferous Limestone and Cefn-y-Fedw Sandstone have been examined for a distance of about 40 miles, and they all present a somewhat persistent character excepting the Arenaceous Limestone of Cefn-y-Fedw, which gradually becomes the Upper Black Limestone of the north of Flintshire. On Cefn-y-Fedw the Arenaceous Limestone is a white sandstone which effervesces in acid, but at Holywell and Prestatyn it is a dark, thin-bedded earthy limestone, while in the intervening country it is a series of interstratified beds of sandstone and limestone. The fossils found at the extremities of the area differ as much as the lithological character. In my paper on the country around Llangollen I described the Arenaceous Limestone as the base of the Cefn-y-Fedw Sandstone, but in describing the north of Flintshire I shall be compelled to consider it as the top of the Carboniferous Limestone. Probably the conglomerate at the bottom of the Lower Sandstone is the most convenient base for the Cefn-y-Fedw Sandstone, though the horizon of a coral reef, with an overlying plant bed, which extends many miles along the top of the Upper Grey Limestone, from Llangollen to Prestatyn, would be a clear palæontological line of division. Near Llangollen, however, the coral bed, or what is the top

of the Carboniferous Limestone there, is 400 feet below the top at Mold. However, as both lines are very clearly defined, it is of little importance which is adopted, for there is no break in conformity between the Carboniferous Limestone and the Cefn-y-Fedw Sandstone either in Denbighshire or Flintshire.

Newbridge, or Acrefair.

The first section (No. 1) was published by the Geological Survey (Vertical Section, No. 24), in which the succession of the "Farewell Rock," as it is named, is shown to be a series of sandstones with a conglomerate base, interstratified with three thick bands of shale, with an entire thickness of 640 feet. It agrees with my own sections, especially as it may not have been taken over the same ground as mine. All the sandstone is named "Farewell Rock," the conglomerate at the base alone being otherwise designated. The only correction necessary seems to be with regard to a bed of coal shown in the Cherty Shale, which I have elsewhere shown to be absent. As the whole of the strata in this Vertical Section are not exposed about Newbridge, or Acrefair, it is probable that it is the result of a general examination of the surrounding country, for two horizontal sections of the strata about a mile to the north have also been published by the Geological Survey.

Dee Bridge, or Pont-y-Cysyllte.

A Vertical Section at Dee Bridge, or Pont-y-Cysyllte (No. 2) shows the strata exposed along the bed of the river Dee. Nothing could be clearer than the succession of the upper beds of the Cefn-y-Fedw Sandstone, consisting of sandstone and shale, with thin beds of limestone, the Dee Bridge Sandstone, and another shale, succeeded by the Aqueduct Grit. The lowest bed in the 50 feet of Lower

Shale and Limestone was said by a miner to contain "mussel shells," but I was not able to find them, though from what I have found in corresponding beds in other places should not expect to find *Anthracosia*. In the overlying Dee Bridge Sandstone there is a matted mass of Stigmaria and Lepidodendron. The thickness of the Upper Cefn-y-Fedw Sandstone exposed is 180 feet, and it is faulted against the Wenlock Shale, so that the Lower Cefn-y-Fedw Sandstone does not occur in the section.

Garreg Pengruch and Pen-y-Gaer.

The Section (No. 3) is the result of observations over ground about a mile to the north-west, where the strata are well exposed. With exception of an additional band of shale, the succession is much the same as in the previous sections, which might be expected considering the short distance between them. The strata extend from Australia, near Trevor Station, where the Aqueduct Grit is quarried, up the hill Garreg Pengruch, near Whalley's Monument, where the inferior beds occur. The thickness of the whole from the base of the Lower Sandstone and Conglomerate to the top of the Aqueduct Grit is about 680 feet.

Tynant Ravine and Tyfyn-uchaf.

The Section (No. 4) is two miles further north, and presents the same order of succession. The lower strata occur on Cefn-y-Fedw, where the Cherty Shale crops out, and contains numerous Carboniferous Limestone fossils. The upper strata occur at Tyfyn-uchaf, where the Lower Shale with Limestone is also crowded with fossils, and is succeeded by the Dee Bridge Sandstone, the Upper Shale, and the Aqueduct Grit. Above the Grit a thick shale comes in with the Aqueduct Coal, 30 feet from the base. It is not necessary to describe the subdivisions of these sections more in detail, for I have already done so elsewhere, but it is obvious

that, taken together, they show clearly the succession and thickness of the formation in the country south-west of Ruabon, which is on the Coal-measures. The total thickness is about 648 feet as nearly as can be measured and estimated.

Sweeney.

Section (No. 5), at Sweeney, a few miles south from Oswestry, shows that the Cefn-y-Fedw Sandstone becomes almost altogether a sandstone formation in that direction. The whole of the strata crop out along an old tramway, and several quarries expose the beds more fully. The Arenaceous Limestone is not exposed, but the conglomerate base of the Lower Sandstone crops up and is well exposed. It is a soft red sandstone, with numerous quartz pebbles and the overlying strata are red and yellow, very much resembling the soft beds of the Trias, as remarked by Sir R. I. Murchison, many years ago in his "Silurian System." Higher in the series there is a hard, white sandstone, and still higher two bands of red and pink sandstone, with some thin seams of shale, which probably represent the Cherty Shale, though of a very different lithological character. *Productus semireticulatus*, and other species are abundant in the pink sandstone and shale, as first noticed by Mr. D. C. Davies, F.G.S., of Oswestry, many years ago. It seems doubtful whether the soft white sandstone at the top of the section, called the Sweeney Mountain Sandstone, represents the Aqueduct Grit. It is faulted against the Coal-measures, and probably represents the middle Cefn-y-Fedw Sandstone, all the upper beds including the shales and Aqueduct Grit, having been denuded. The total thickness of the strata is 430 feet.

Graianrhyd and Tryddyn.

During the last summer I frequently visited the country to the south of Mold, and completed the section, (No. 6,) which exhibits the Cefn-y-Fedw Sandstone, between Graian-

rhyd and Tryddyn-fechan. Nearly the whole of the strata between the Limestone and the Coal-measures is exposed in this district, so that the section is an important one. The Lower Sandstone is very friable, and occurs at the former place in the form of sand, but being so soft it is seldom exposed on the surface, so that the Cherty Shale, which has become much thicker, appears to rest on the Carboniferous Limestone. At the top of the Cherty Shale there is a thick sandstone, which is succeeded by shales and sandstones, with the Aqueduct Grit and the Coal-measures all well exposed, between Graianrhyd and Tryddyn-fechan. I and Mr. A. Strahan, F.G.S., found *Spirifera bisulcata* and *Streptorhynchus crinistria* in the upper beds of the Cherty Shale on the banks of the stream, half a mile east of Graianrhyd, but I have not found fossils in the upper beds. There is a cliff exposure of the Upper Cefn-y-Fedw Sandstone on the east side of the river Terrig, at Tryddyn-fechan, where I was able to measure and minutely examine the strata, and the result is shown on the section. The thickness of the whole of the Cefn-y-Fedw Sandstone is about 449 feet.

Holywell and Prestatyn.

At Gwern-y-mynydd, near Mold, the thickness of the Lower Sandstone is only 32 feet, and it thins away rapidly to the north, so that at Holywell and Prestatyn no trace of it remains. The Cherty Shale, however, is well developed, and gradually changes from white to a dark brown and black. It also assumes the character of a sandstone, and occurs in beds from a few inches to a foot in thickness, which have been more or less changed into chert, flint, and sometimes in hand specimens into opal. At Holywell, the term Cherty Sandstone is more descriptive of its lithological character, for it presents a very slight resemblance to the Cherty Shale of Cefn-y-Fedw, though on the same horizon. Between Holywell and Prestatyn it is the most important subdivision, and is about

250 feet in thickness. It rests on the Upper Black Limestone with the Gwespye or Upper Cefn-y-Fedw Sandstone above it. Sections 7 and 8 show the succession at both localities, but the Gwespye Sandstone, which is 120 feet thick near Prestatyn, is only about 30 feet at Holywell where the base alone is visible—the higher beds having been denuded.

Both geographical and lithological names of formations and their subdivisions become inappropriate when the strata alter much at a distance from the typical locality. From the sections (1 to 8) it will be seen that the names of all the subdivisions at the south cannot be applied to the strata at the north of the country described. Even the term Cefn-y-Fedw Sandstone seems inapplicable to the strata, on the same horizon, at the north of Flintshire, and probably Flintshire Cherty Sandstone would be the most suitable if it were understood that it correlated with the Cefn-y-Fedw Sandstone of Denbighshire. The Carboniferous Limestone, formerly the Mountain Limestone, was originally called the Derbyshire Limestone. If we had had from the first the Derbyshire Carboniferous Limestone, the Yorkshire Carboniferous Limestone, and the Flintshire Carboniferous Limestone, &c., it would not have led to the assumption that the Limestone always represents exactly the same period in time.

The sections I have described tend to prove that the Cefn-y-Fedw Sandstone is a well defined series of strata between the Flintshire Carboniferous Limestone and the Flintshire Coal-measures. It is impossible to ascertain whether the beginnings and endings of these latter formations correspond with those of similar formations in Derbyshire, Yorkshire, and other localities. Professor Green many years ago suggested that the Yoredale and Millstone Grit series were represented on Cefn-y-Fedw.* Considering that no instance of unconformity has been observed between the

Lower Carboniferous rocks of North Wales it is possible that his opinion may be correct, but it is also possible that the Yoredale and Millstone Grit may be represented by the lower part of the Flintshire Coal-measures.

In the recent report of the Devonian and Carboniferous Committee, in connection with the International Geological Congress, the desirability of giving geographical names to isolated formations was very strongly recommended. In giving such a name no opinion is given as to the precise age of the Cefn-y-Fedw Sandstone. The numerous fossils that occur are the same species as in the underlying Carboniferous Limestone, viz.: Plants, Corals, Encrinites, Crustacea, Brachiopoda, including seven species of *Productus*, Lamellibranchiata, Gasteropoda, and Cephalopoda, including *Orthoceras giganteum*, 3ft. 11in. in length, which also occurs in the Upper Grey Limestone. These were all found near Oswestry and on Cefn-y-Fedw, but the number of species has been recently increased by the discovery of another locality near the top of the Cherty Sandstone at Pentre Halkin, Holywell. As the fossils found in the Cefn-y-Fedw Sandstone are all common Limestone species that occur in Denbighshire and Flintshire, it seems possible that the formation is an Arenaceous continuation of the Carboniferous Limestone. The inference is, that the marine species lived on until changes in physical conditions produced Coal-measures, but the changes were probably very gradual, for the late Mr. E. W. Binney, F.R.S., found *Goniatites*, *Bellerophon*, *Aviculopecten papyraceous*, and *Posidonomya Gibsoni* in the lower Coal-measures at Holywell many years ago. There must, however, have been a Carboniferous Limestone deposited during the period of the Flintshire and Lancashire Coal-measures, though we do not seem to have recognised it.

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* On the Lower Carboniferous Rocks of North Wales "Geological Magazine," Vol. iv., p. 11., 1867.

The PRESIDENT said he had not gathered from Mr. Morton's paper with what group of rocks he correlated the beds he had described. It was contended by most geologists that they belonged to the Millstone Grit, and they were described as such, he believed, at Bristol and other places where they were found to contain a considerable number of fossils in great variety. Mr. Green, on the other hand, in writing on the geology of the district, held that these beds were of Yoredale age. He (the President) visited the district some years ago, and the conclusion at which he arrived was that the beds belonged rather to the Yoredale series than the Millstone Grit. The palæontological evidences also seemed to bear out that view.

Mr. MORTON, in reply to Professor Dawkins, explained more precisely one of the sections exhibited, and with reference to the remarks of the President, said that he had purposely avoided correlating these beds with formations elsewhere, for the simple reason that he thought it was impossible to do it. Professor Green gave it as his opinion that the beds represented the Yoredale and Millstone Grit; but he (Mr. Morton) thought some progress had been made in geological matters during the last twenty years, and few would now be disposed to correlate beds in that way, for they had no means of coming to any certain conclusion. If they were to take the fossils alone they would refer the rocks to the Carboniferous Limestone: they were all Carboniferous Limestone fossils. The conclusion arrived at by the International Congress was, that it was not advisable to try to fix the precise age of such beds. They could not do it unless they could by some means get a section of the country between there and Yorkshire. In no other way could they get at it with certainty.

Professor BOYD DAWKINS: I feel much obliged to Mr. Morton for the explanation he has given me. I was under

the impression that the dark-coloured beds on the section represented coal seams, and I was desirous to know because some years ago I happened to be walking across the fields from Cefn in the Vale of Clwyd to Bodlewyddan, when I observed a bed of coal about the horizon of the land marked "F" on the section. The seam occurs in dips at a high angle to the north and about six inches thick in the outcrop. It seems to me the occurrence of that bed of coal is worthy of record. With regard to the general question of the beds between the Mountain Limestone and the Coal measures in that district, I certainly think we ought to feel very much obliged to Mr. Morton for the trouble he has taken in working out a very difficult series. The condition of things in that part of the country as compared with Derbyshire and the adjacent parts of Lancashire and Yorkshire is simply this. The old Silurian region in those times represented the uplands, and during the time when that vast thickness of Mountain Limestone was being accumulated in Derbyshire there was a much less thickness of limestone being formed on the borders of the ancient Silurian region of Wales. Then, while these beds of sandstone—the old sandbanks and so on—were being formed along the margin of what were then the Carboniferous uplands of the Welsh area there were other beds being formed further away. Consequently, as Mr. Morton says, it is impossible for us to correlate with absolute certainty the relative age of the old shingle beaches and sandbanks formed round the margin of that shore with the accumulations of sand and mud that were formed further away in the Derbyshire area. As far as the fossils go, I feel inclined to believe that the beds in question are more properly classified with the Yoredale and Mountain Limestone series. The fossils of the carboniferous limestone range up into the Yoredale shale, and the Yoredale shale was merely a mud bank which happened to be thrown

down in an area in the deeper and clearer waters of which there were sufficient coral and mollusca living to accumulate beds of limestone. It is a very important thing, in every point of view, for us to be able to understand what these thick beds of sandstone really are. I know a great deal of money has been wasted in hunting for coal in some beds of sandstone in that district; and we ought to feel much obliged to Mr. Morton for having unravelled the geological history presented by these beds.

Mr. DICKINSON: I think, without going into refinements, but speaking roughly, these conglomerates may be correlated with the Millstone Grit. Those who know the northern out-crop of the South Wales coalfield at Dowlais, will know that the Millstone Grit is there solely represented by about thirty yards of plum-pudding stone, and in the North of England west of the outcrop of the Newcastle Coalfield is represented by two or three beds, first of a gritty character, but afterwards so changing that they become fine sandstone. I should, therefore, myself, correlate them with the Millstone Grits. There are few parts of the country where there is such a development of Millstone Grit as there is in Lancashire. It is something unusual.

The PRESIDENT: When I visited the district it struck me that the lithological character of these rocks was so different from the Millstone Grit, of Lancashire and the North of England, that I had a difficulty in classifying them. But when I found that they were interbedded with black shales which had a purely Yoredale aspect, containing Carboniferous Limestone fossils, and that they occupied the position which the Yoredale beds usually do, it struck me that they might much better be classified with the Yoredale rather than Millstone Grit. I know that the majority of geologists are in favour of their being considered as Millstone Grit, and that they have

generally been described as such. I do not know anyone who has classified them as Yoredale beds except Mr. Green and myself. Mr. Davies, of Oswestry, in whose company I examined the rocks, and who is an authority upon that group, differed with me upon this point. After hearing Mr. Morton's description, I still think that if we are to classify them at all the rocks fall in very much better with the Yoredale than with the Millstone Grit. Of course this is merely a matter of opinion, and the next person who goes over the ground may come to a different conclusion. Mr. Morton, I think, has acted discreetly in not committing himself to any classification.

Mr. DICKINSON: Is it quite clear that the upper beds are conformable with the Old Red Sandstone there?

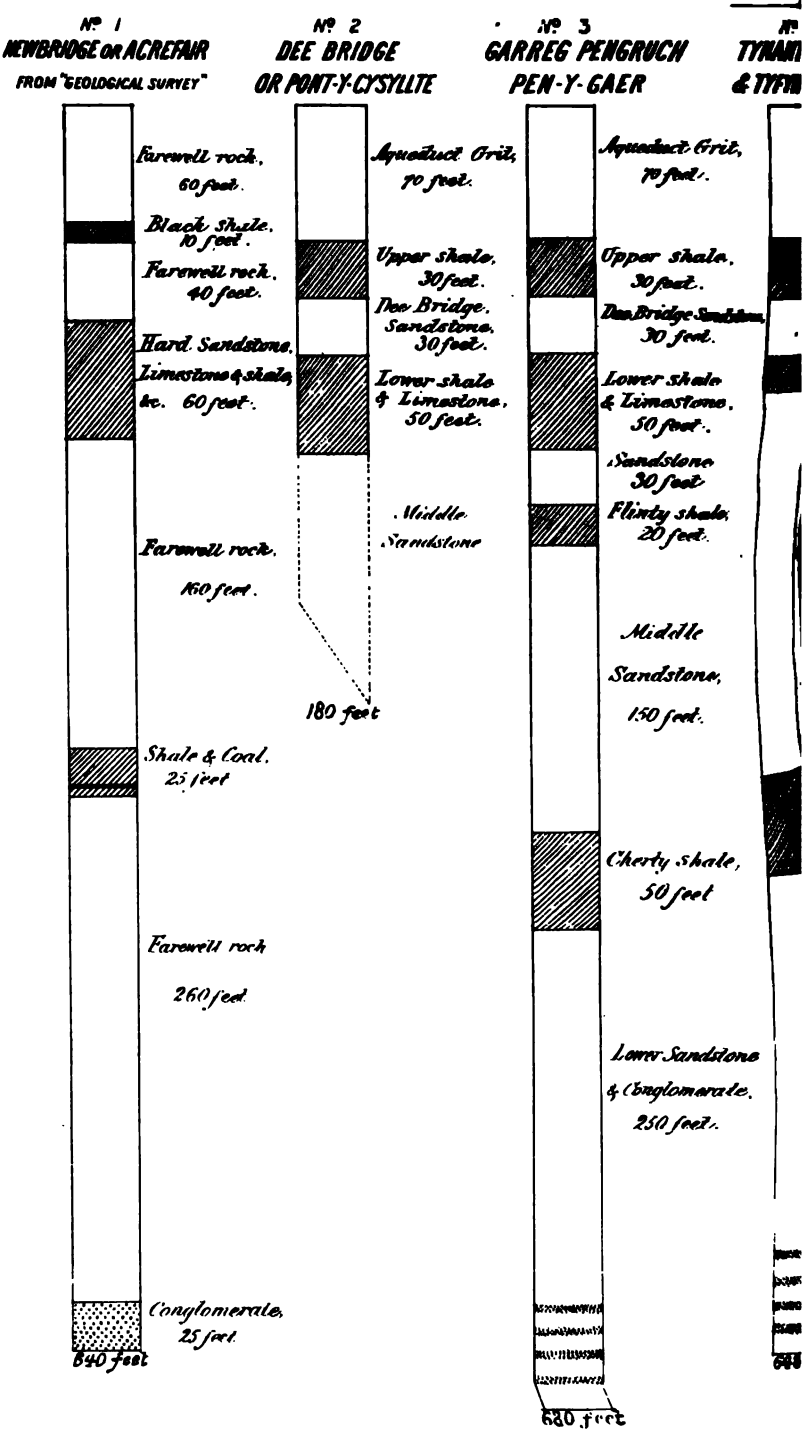
Mr. MORTON: Yes, quite conformable.

The PRESIDENT: Is it not a question whether this is Old Red Sandstone at all—or Coal measure?

Mr. MORTON: My idea is that the Carboniferous Limestone of Flintshire is younger than some other Carboniferous Limestone of Derbyshire for example. In the very lowest beds there you have a complete set of Carboniferous fossils. They must have migrated from some other area for there must have been Carboniferous Limestone before that, and, such being the case, the Carboniferous Limestone I refer to would be of the same age as that Old Red Sandstone of Dengighshire. I do not think it ought to be called Old Red Sandstone. Then, higher in the series, in another locality, you have the Old Red Sandstone below some middle beds in the Carboniferous Limestone. It only shows the danger of correlation at all, when you have little or no data to go upon. Of course I had no intention of correlating these beds with any other; in fact, I happened to be one of the Secretaries of the International Geological Congress—that is, of the Devonian and Carboniferous Committee—and it was the

general conclusion of the members of that Committee that it would be very dangerous to correlate beds in a district that was disconnected with any other, that is to say, in an isolated locality—that it was better to give geographical names that did not commit an author to any correlation whatever. Accordingly I called the formation described the Cefn-y-Fedw Sandstone. I doubt very much, as I said before, whether we shall be ever able to correlate it. Referring to the observations of Professor Dawkins, I believe there is not, in the Vale of Clwyd, any Cefn-y-Fedw Sandstone. I thank you for the kind manner in which you have received my paper. It embodies an investigation carried on for many years. I had the pleasure, many years ago, of going over the ground with your President; and, though I have continued at the subject ever since, I am still indisposed to give any other than a local name to the strata I have described.

TABULAR VIEW OF



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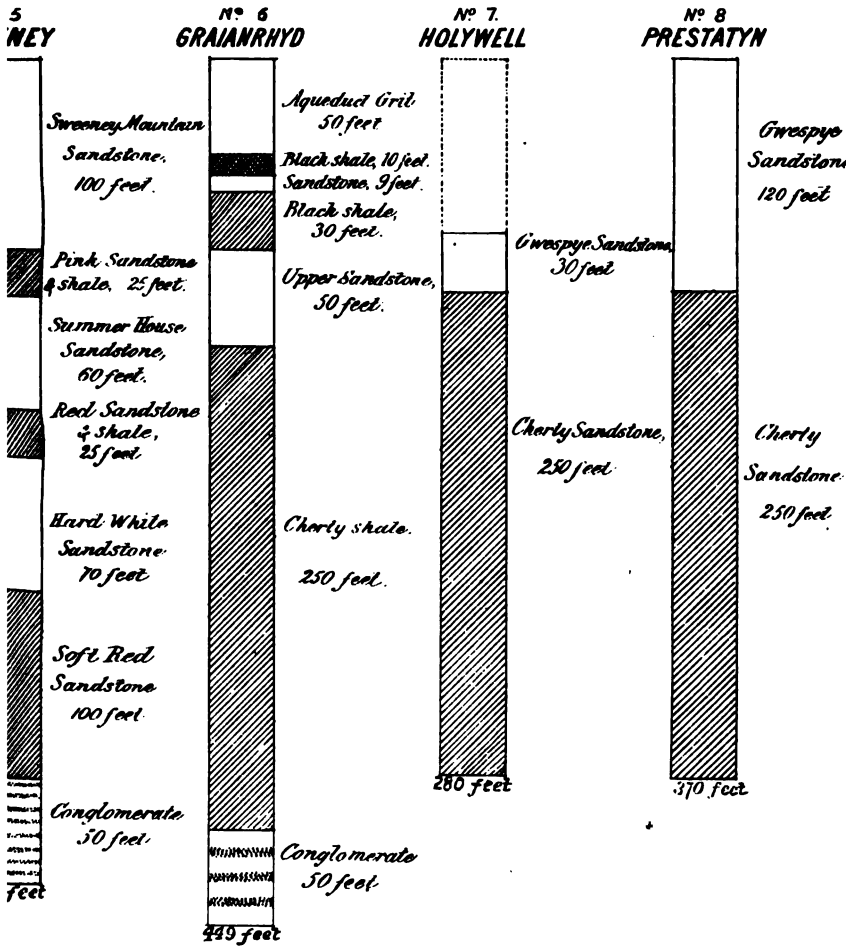
Illustrating Mr Morton's Paper.

(- FEDW SANDSTONE.



TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XVII. SESSION 1882-83.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 6th day of March, 1883, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

NOTES ON FAULT-ROCK.

BY MR. G. HENRY KINAHAN, M.R.I.A.

Fault-Rocks, although they appear so simple when understood, yet seem a stumbling block to many enquirers. This I have observed in many descriptions of mines and mineral veins, but especially in an otherwise very able paper that I have just read. The writer of this paper evidently was aware that there were two different classes of country associated with the mineral veins, one of which he calls "the country," while the other he calls "the hard country," yet he does not appear to be aware why there was a difference between them. It may therefore be allowable to lay before this Society some remarks on fault-rocks; which however will more specially refer to those associated with

the older rocks, because in these countries, as far as my experience goes, they are not often applicable to faults in rocks of Silurian age (*Lower Old Red Sandstone, or Lower Devonian*), or those belonging to the younger groups.

Fault lines, as is generally known, may be only slides, that is, the rocks on one side of the line slide down along those of the other side, without forming a fissure, or the opening was so small that only a thin seam of filling stuff was required to close it; but along some faults, conspicuous fissures did form, often of considerable dimensions, which had to be filled. Some of these, such as those that are now mineral veins, seem to have been filled from minerals in solution, others were filled by stuff brought in from above, or along them, and the rest by a combination of both, or by melted matter intruded into them. The second, to which I would specially refer, may have been irregularly filled, often by brecciated stuff, especially if in hard rocks that are inclined to break into shingle; but the majority of these fissures seem to have been more or less regularly filled, the filling stuff having a structure allied to bedding, that is consisting of plates or layers having more or less uniform strikes and dips. If the walls of the fissure are nearly parallel this structure has a sort of parallelism to both, but if the fissure is of uneven widths the structure usually coincides more or less to the foot wall, while it is oblique to the hanging wall, as if the fissures had been very gradually opened, and each plate or layer having been separately accumulated. It is, however, quite possible that these suppositions may be all erroneous, as the bedlike structure of the fault-rocks may be an introduced structure allied to slaty-cleavage; we know that in some unaccountable way grit ribs or layers have come into the argillaceous rock apparently along with the cleavage as their dips and strikes coincide with its planes. In a similar way the grit ribs in fault-rock may possibly

have been introduced if the structure in it is due to cleavage and not to deposition.

To whatever circumstance this structure is due, it is not uncommon in fault-rock, and if the fault fissure is wide it gives a character to an area of greater or less width, in which the rocks may easily be mistaken for the normal country rocks. I know a channel of fault-rock from 100 to 200 or more fathoms wide, while the Indian geologists speak of enormous width in their channels.

Mr. W. J. Henwood in his able treatise on Mineral Veins, tells how vein fissures may form in older ones, and thus give "veins within veins." This is illustrated in the Glandore Mineral Channel, County Cork. The original fissure was filled with conglomerate stuff made up of fragments of the country rocks, the second fissure which ran very regular, that is, more or less parallel to the walls of the first, was filled with iron ore,* and the third system (which is very irregular, the fissures sometimes running with the iron ore, at other times across it or leaving it altogether and being in the conglomerate) were filled as far as can be seen with Manganese ores. This channel was of no great width, but others are much more considerable, such as those at Ovoca, County Wicklow. In these wide channels of fault-rock a newer fissure may form, or two or more quite independent fissures, as shown in the accompanying diagrammatic plan and sections, which although not made to scale, represents what has taken place in parts of the Ovoca channel.

North and south of the fault-rock channel are the country

* The lode, when I last visited it, had not been proved in depth, while there were strong reasons for supposing that the iron ore was only the back, or gossan of a coppery ore; if such is the case, the fissure was first filled with coppery ores, while the iron ores, that were afterwards ruptured by the third system, are the result of decomposition and chemical changes (methylotic metamorphism) in the original lode.

rocks that strike and dip independent of it. In the channel, independent of its structure is the main lode, supposed to fill a fissure second in age, while coinciding with the structure of the fault-rock is a third system (yellow copper ore lodes). The main lode has been described by all old writers on the subject, except Mr. W. W. Smyth, to run "very nearly with the country," and the yellow copper ore lodes are described as "running and underlying with the country," while in point of fact these relations are those that exist between the two sets of veins and the structural plans of the fault-rock, the normal "country rock" having relations quite different.

Even the mineral lodes may be made up of fissures within fissures, as suggested by the accompanying plan, which is a cross section of upper Cronebane, or the Magpie mine, kindly reduced for me, from his plan, by Mr. P. H. Ardfall, Agent at the mine a few years ago; from it will be seen that some of the accumulations appear to be newer than others, and to have filled shrinkage fissures.

Numerous other places could be mentioned, but enough appears to have been given to illustrate the subject; they showing that mineral veins may occasion channels of fissile fault-rock, the structure of the latter giving it characters very similar and easily mistaken for normal country rock, while in reality this structure is quite independent of the country. Mistaking this structure for the bedding of the country, has led to innumerable errors, both by those writing of mines as also those working them.

In geological surveying, such dykes of fault-rock are often very puzzling. On page 319 of the "Geology of Ireland," I give a map of the fault-rock in Kilmacrea Pass, County Wicklow. Here the strata, or county rocks, bears nearly SW. and NE., while the structure of the fault-rock runs nearly N. and S., it being made up of shales (killas), with

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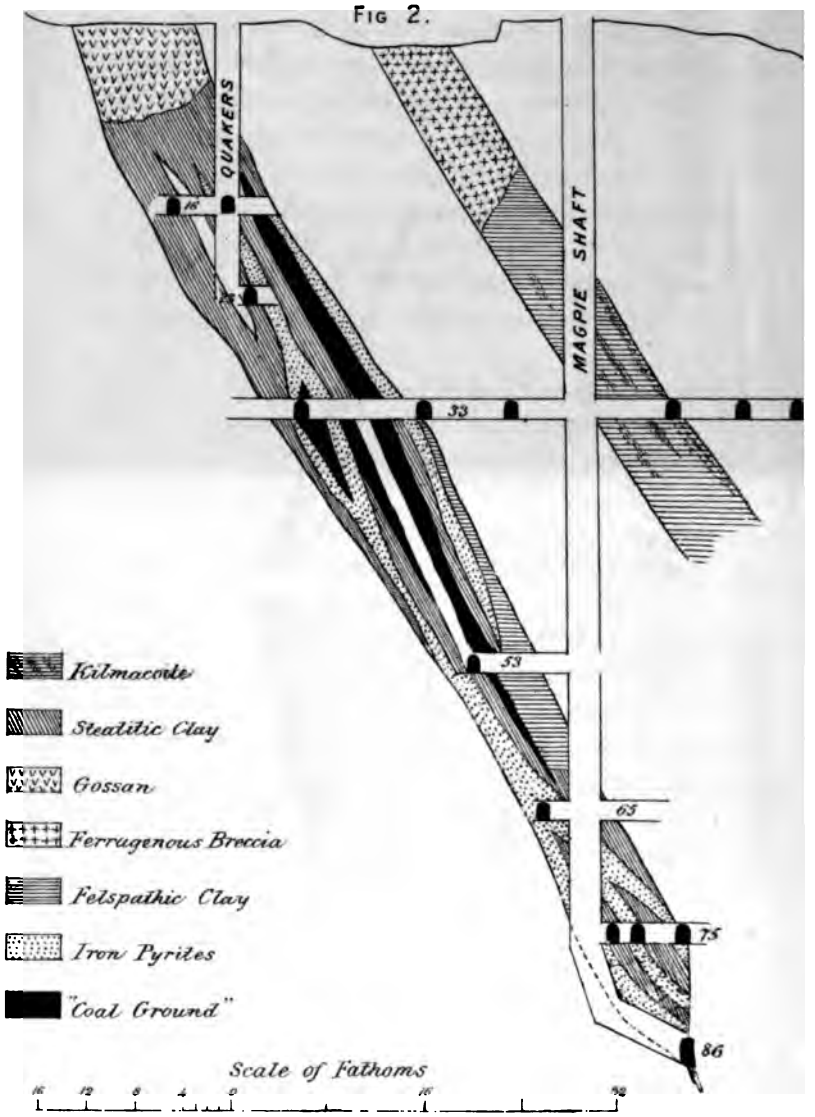
To Illustrate Mr Kinahan's Notes on Fault-Rock

CROSS SECTION ENLARGED
(CRONEBANE) UPPER MINES (CO·WICKLOW.)

FIG 2.



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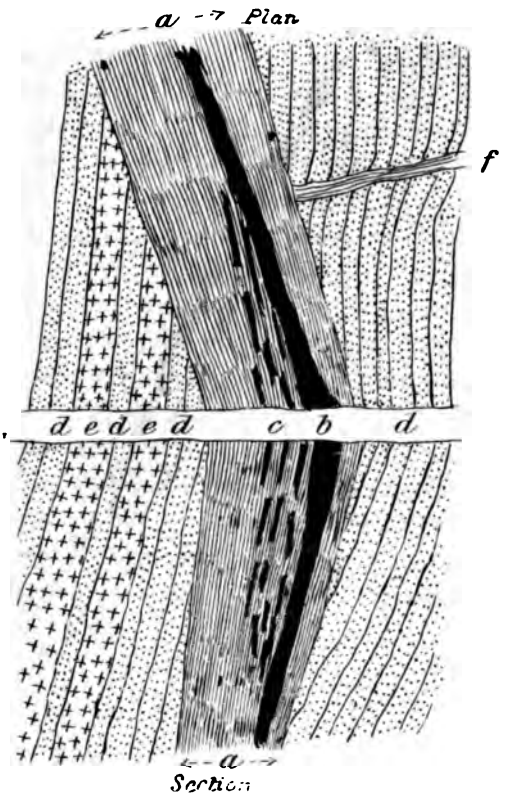
To Illustrate Mr Kinahan's Notes on Fault Rock

DIAGRAMMATIC PLAN AND SECTION

of a Channel of "Fault-Rock" showing its relations to the "Country Rock" its structure, and the fissures that subsequently formed in it, which are now Mineral Veins.

FIG 1.



a. First fissure-Channel of Fault Rock.
b. Main lode - 2nd fissure
c. Yellow Copper Ore lodes - 3rd fissures
d. Country Rock
e. Felstone in Country Rock.
f. Fault in Country Rock that does not affect the Channel of Fault-Rock.

grit ribs, which have been mistaken for genuine stratification. Another class of fault-rock to be mentioned is that found between the two walls of the fault, consisting of masses of the country rocks, ruptured and displaced, but not entirely broken up. In places in the County Wexford, in faults of this class will be found unbroken portions of beds of limestone and other rocks running continuous for many yards, some being of such length that they may easily be supposed to belong to undisturbed strata; but that they are in wide faults is proved by their running transverse to the strike of the country rocks at both sides of the fault. When partially unbroken strata occurs in such faults it often misleads, especially in a drift-covered country, where few rocks are exposed except in the deep valleys; because if such rocks can only be mapped, the strata will appear to run in quite different directions to those in which they really run. Such dykes of broken strata often occur in West Galway, where there is every opportunity for studying them, on account of the extensive tract of country in which the rocks (metamorphosed Cambro-Silurians and Cambrians) are nearly continuously exposed. The study of these fault-rocks is most important, as the structure in similar dykes have led some observers to believe in supposed unconformabilities that do not in reality exist.

SECTION OF STRATA PASSED THROUGH IN ARTESIAN WELL-BORING AT ARDWICK.

By Mr. R. T. Burnett, F.G.S.

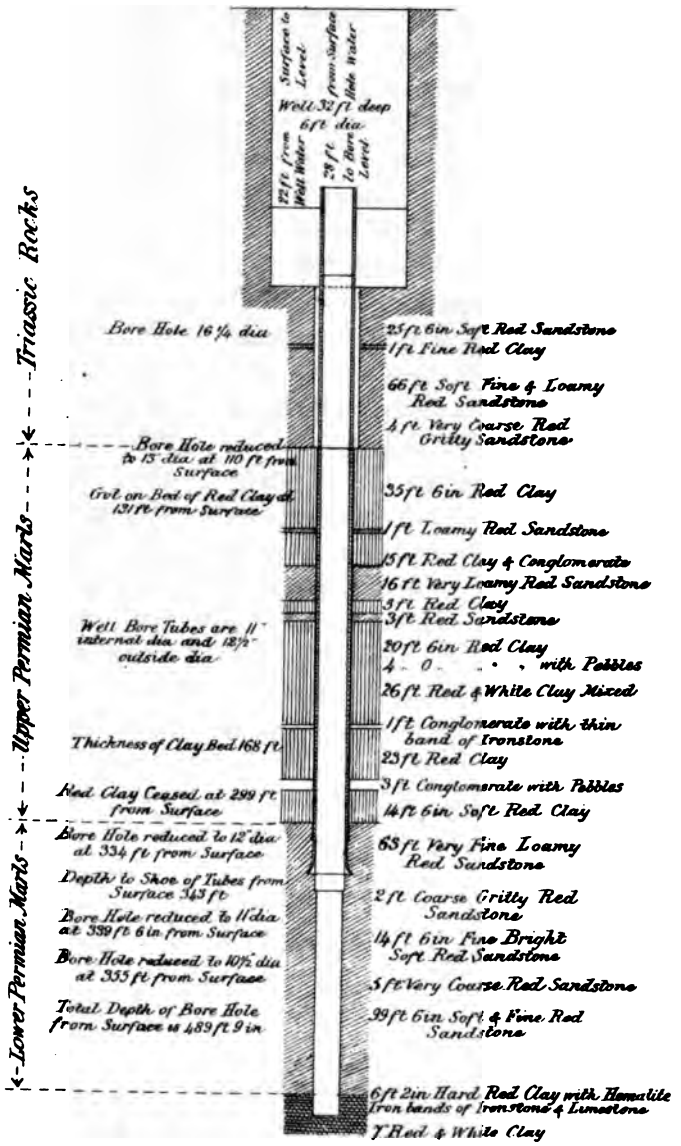
The section which I wish to bring before you is that of strata passed through in a well-boring which was executed about two years ago by Mr. Charles Chapman, Engineer, Salford, at the Brewery of Messrs. Deakin, of Broadie Street, Ardwick. The boring was commenced at the bottom of a new well thirty-five feet deep which had been excavated in the floor of the cellar of the Brewery. The boring was carried down to a depth from the surface of 489 feet, the section passed through being given herewith.

It will be seen, that after passing through upwards of 120 feet of new red sandstone the boring entered the red marls of the upper permains, which together with their intercalated sandstones were proved to be about 167 feet thick, and that at a depth of 299 feet from surface these marls ceased. The boring was continued further to a depth of 186 feet through lower permain sandstones, at the base of which was a hard red clay. The hole went nearly seven feet into this red clay, and operations were then stopped, an abundant supply of water having been obtained. In the hard red clay a band of hæmatite iron ore was met with, overlying what is described in the section as "red and white clay mixed." This would represent the top of the upper coal measure. The late Mr. Binney said that "at Ardwick the permain beds repose on the upper part of the limestone series, and that at Patricroft they overlap the whole of the 'series' and rest on the hæmatite still further down in the series."

With regard to the hæmatite bands, Mr. Hull in his memoir of the geology of the county around Bolton-le-Moors,

SECTION.

of a Bore Hole at Mr. J.H. Deakin's Brewery. Broadie St. Ardwick, Manchester. brought before the Society by Robt. T. Burnett F.G.S.



says "even the band of hæmatite iron ore of Patricroft, which at the east side of Manchester reaches the surface upwards of 500 yards beyond the boundary of the permains strata, strikes the base of these beds of Patricroft." Further, that "it (the hæmatite of Patricroft) has been identified by Mr. E. W. Binney with the band which crops out on the banks of the Medlock below Beswick Lodge." Now if the Patricroft hæmatite and that cropping out at Beswick be the same, may we not assume that this band, which at Ardwick was not reached at a less depth than 489 feet, is also the same? If the same, then the fact of it being found at such a great depth so near to its outcrop, indicates the presence of a great fault. If so, does this fault exist between the boundary at Ardwick and the outcrop at Beswick, which are comparatively speaking a very short distance apart, or will it indicate that a great synclinal trough once existed between Patricroft and Beswick, caused by a pre-permian upheaval of the coal bearing rocks, which trough subsequently became filled with permian and triassic deposits? The deep part of the synclinal being at Ardwick would point to a gentle slope existing towards Patricroft, at which place the hæmatite band strikes the base of the permains at an angle of 10°, and a sudden curve with a high gradient to Beswick, where Mr. Binney said it cropped out. I believe that the hæmatite at this depth indicates the presence of a great fault, but as to what it really may point to I leave it to the members to discuss, for which purpose I have brought the matter forward.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XVII. SESSION 1882-83.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 3rd day of April, 1883, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., J.P., President,
in the Chair.

NEW MEMBER.

Mr. THOMAS SHORTREDE, Winstanley, near Wigan, was duly elected a member of the Society.

ON RESPIRATORS AND LAMPS FOR PENETRATING NOXIOUS GASES.

BY JOSEPH DICKINSON, F.G.S.

My attention having been requested to the subject of a respirator and a lamp for penetrating noxious gases in mines, I have put together the following observations, which I hope may prove useful:—

DE LA BECHE AND PLAYFAIR'S BAG.

Sir Henry De la Beche and Dr. Lyon Playfair, in a report to Viscount Canning, June 1st, 1846, point out, "that after an explosion, a sufficient quantity of oxygen remains to

support the respiration of those who survive its effects, were it not for the presence of carbonic acid. This gas, when present in no greater proportion than in one or two per cent., is capable of producing the most injurious effects. It has therefore been suggested that cheap mixtures made of substances capable of absorbing carbonic acid, such as Glauber salts and lime, would prove useful to those who try to aid the sufferers after the explosion. Such a mixture, placed in a course bag, and applied to the mouth, would effectually absorb the carbonic acid, and prevent it exercising an injurious effect on respiration."

Dr. Hutchinson's Respirator, Lamp, and Means for Reviving Persons.

Mr. J. Hutchinson, M.D., in his evidence before the Lords' Committee in 1849, after speaking of being able to hold his breath for 2¼ minutes after making several deep inspirations and expirations, proposed the carrying of 4 or 5 cubic feet of air in a bag, which would last a person with care half an hour; and suggested that a mask might be employed, with the expired air instantly escaping off into the atmosphere. Masks, he said, had been used with long tubes, but we cannot breathe through a tube of 3 or 4 inches in length for any time without feeling inconvenience, upon the same principle as the partial return of water in the ebb tide is brought back by the flowing tide; so, if we employ a tube of any length, we are always inhaling a part of the previously expelled air, therefore the point is to expel it clear out into the atmosphere as soon as possible. Another objection to certain improvements is, that sometimes they make a mask, through which you must inspire by the mouth, and expire by the nose. Now, all plans for a miner in time of danger must be such as requires no attention to his respiration: that he cannot breathe wrongly. He has quite enough to do to take care of himself in other ways,

Trans. Man. Geo. Soc. Part VII. Vol. XVII.

Mr Dickinson's Paper

DIAGRAM (No 1.)

To illustrate the Evidence of J. Hutchinson Esqr M.D. of 29th June 1849.

Fig. 1.

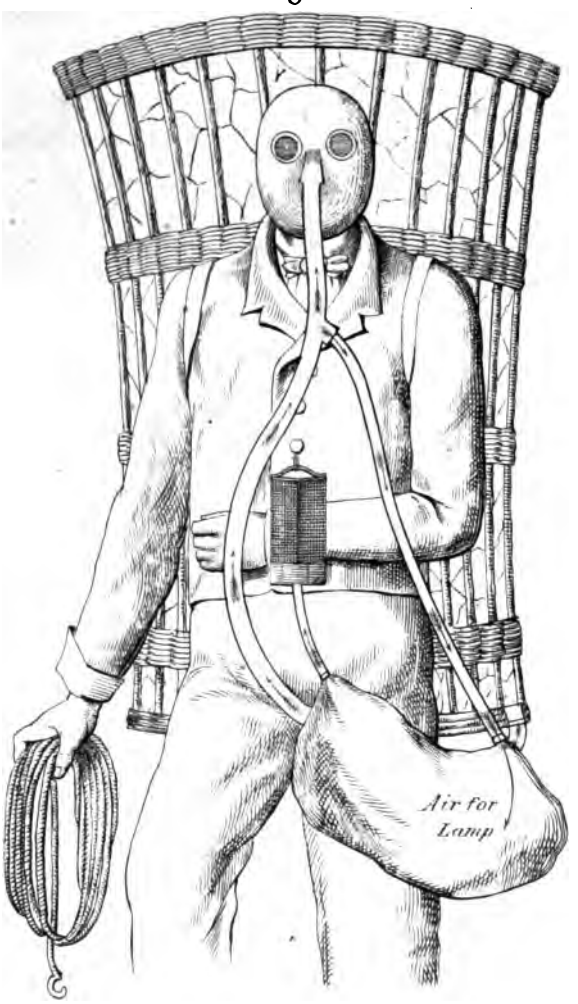


Fig. 2

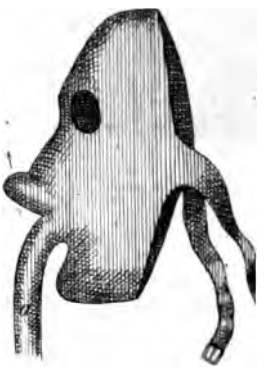


Fig. 3

that he may breathe with either nose or mouth. A mask is used in the drains in Paris, connected to a large bag as a reservoir, a kind of arrangement of this order (showing a diagram of the same, Diagram No. 1, Fig. 1), a bag containing so many cubic feet of air, carried in a basket which keeps it in its place. I propose (he says) a mask like Fig. 2, strapped on to the head; a mask is better than a skull cap, because the ears are exposed, and hearing is an important sense in time of danger, and the head is kept cooler by a mask; this is to be connected with a bag, as in Fig. 1, which bag may also be connected with a lamp. Fig. 3 is a section, showing the arrangement of the valves for directing away the expired air immediately into the ambient atmosphere; if this is not attended to, I have found the pulse raised, or heart's action, to 160 beats instead of 80 beats per minute; but even a bladder of pure air, containing 300 or 500 cubic inches of fresh air, or perhaps 1,000 (which would be only a small bladder), in his hand, this supply would serve a man a long time. I press another point (he says), namely, that he should not be dependent upon any tube for his air, communicating with "out-by," or at a distance, for such as a tube "following" him, may be crushed by a stone falling, and he or others in confusion may walk upon it, which would be death to the miner in question; in fact, anything depending upon people at a distance is uncertain, and therefore bad; he should have it all with him, only depending upon himself; and I am sure that a bag containing fresh air would be a means of saving many lives after an explosion, from the cases which I have seen; I speak of it because I have seen it. The air-bags should be filled at "bank" with *bellows*, and not with any oiled or greased "syringe." "It is the *quality*, not the *quantity*, of the air upon which we chiefly depend." "When a man is brought out of an impure atmosphere, in a state of insensibility, the best treatment is for any one to

put his finger down his throat, and try if he can make him vomit; I would urge this. Inflation or insufflation of the lungs has been spoken of, by apparatuses like pumps or bellows; but they are generally dangerous." "When we employ bellows or pumps to inflate the lungs, we use an extreme or unknown force; we have to expand the lungs against the pressure of the ribs; the consequence is, that we rupture the lungs; we cannot introduce, for physiological purposes, the finest injection into the lungs without rupturing them; I have found that a very little quantity of air produces a rupture; therefore bellows and pumps for resuscitation are unsafe instruments in anyone's hands. Oxygen gas is also mentioned for resuscitation; I would say that we do not know much of the operation of the oxygen on our system. The only gas which we can breathe with impunity is the atmospheric air, and if we breathe pure oxygen, I am afraid we would do more harm than good." The Doctor then quotes a case of a boy brought out of a canal, "when a man said, 'I will restore him,' and he put his mouth to his nostril and inspired all the air out of his chest; consequently the atmospheric air rushed in by the elasticity of surrounding parts, and thus fresh air was drawn into the lungs. Here there was no danger, because this was a natural agent drawing in the air. The expansion of the ribs acts precisely the same as the expansion of the bellows. The lungs are filled by an external act, by the expansion of the walls of the chest; the bellows are filled up the same way, and the boy recovered." "When a man is brought out of a mine in that state, I would first take him into the fresh air; take him out of the way of other people. If you can make him vomit, by means of your finger or an emetic, say a teaspoonful of mustard and water, do so; if he is past that, pressure on the abdomen. Alternate pressure and relief will tend to remove the bottom of the lungs, without any danger, and thus draw air into the chest."

Another Means for Reviving.

Here the writer of this paper may interpolate what has long been impressed upon him as a good way of resuscitating a person until medical aid arrives, namely, to place the person on his stomach, taking care that there is fresh air for the mouth and nose, and to move him from side to side at such intervals as a person breathes, and thus to induce inspiration and respiration.

Mr. T. Y. Hall's Respirator, Safety Chambers, and Lamp.

Mr. T. Y. Hall, in a paper before the North of England Institute of Mining Engineers, in 1853, described his proposal for penetrating dangerous gases. It consisted of safety pipes of any solid material laid down permanently in the floor of the main galleries of the mine, in the direction taken by the air, from the top of the downcast shaft into the workings, and back through the "return" to the "upcast." There being either two pipes laid parallel to each other throughout the whole course, with a junction at a certain point, or a single continuous pipe, to be used for the fresh air and the return.

The circulation of air through these pipes to be constantly maintained by ventilating power; and at intervals of between 40 and 50 yards, boxes or joints to be provided for the purpose of stopping or trapping the air, so as to guide it through portable tubes into an air-tight dress, or into safety chambers where the workmen may take refuge, or into other safety pipes traversing the boards or galleries.

At each junction of the main pipes, provision to be made for admitting air into a glass case for the purpose of containing a stationary safety lamp, to be kept constantly lighted if necessary.

A sufficient number of air-tight dresses and flexible tubes

to be kept constantly in readiness; and the workmen to be frequently practised in the use of the apparatus, so as to become competent to apply it when necessary, with as little delay as possible.

Mr. Hall was a colliery viewer at Newcastle-on-Tyne, and so confident was he of the feasibleness of his method that he said the Government ought to make the construction of it imperative upon all colliery owners on the opening out of every mine.

His paper is accompanied with diagrams showing the arrangement of the pipes in the mine, and the air-tight dresses, flexible pipes from the fixed pipes, portable safety lamp, &c. And it seems to have been submitted, in competition for a prize of 2,000 francs, for a good, simple, and safe mode of effecting the objects in view.

The Denayrouze System.

The Denayrouze's system of exploring in the presence of dangerous gases is described by Mr. Applegarth in the Transactions of the North of England Institute of Mining Engineers, Vol. 25, 1874, as being in some respects similar to that invented by Mr. T. Y. Hall. It is constructed in three ways, to meet three classes of emergencies.

1. To enable a man to enter a room or space that is not far from pure air: this consists simply of an india-rubber tube, some 50 feet long, attached to a mouth-piece fixed to the mouth of the operator, the other end remaining in the pure air, the eyes being protected by glasses affixed to a mask partly covering the face, padded with inflated rubber, so as to adjust itself to all the inequalities of the face and remain perfectly air-tight round the eyes, and at the same time clip the nose. The air, after having passed through the lungs of the operator, is forced out through a valve which prevents foul air finding its way to the mouth after the expiration is effected.

2. When the distance from the fresh air is too great to enable the operator to draw the air through the tube by his lungs, a pump is added which forces the air to him. This necessitates the use of an apparatus which the operator carries on his back, and which is very ingeniously constructed, so as to regulate the pressure at which the air is supplied to the lungs.

3. When the operator has to explore mines at great distances from the pit mouth, and when continuous work has to be done where it is impossible to get a pump applied, highly compressed air is taken down the pit in portable steel reservoirs, and supplied to the regulating apparatus, which forms the distinguishing feature of the second mode described.

It being impossible to describe those portions of the apparatus (such as the regulator, the pump, and the reservoirs) which constitute its chief merit without being able to give detailed drawings, it has been considered desirable to delay any further notice till such perfect drawings can be obtained.

The Fleuss System.

The Fleuss Exploring Respirator was, on the 6th January, 1882, brought before the Manchester Geological Society, at the ordinary meeting. Mr. Martin, as appears in the Transactions (Part xii., Vol. xvi.), said "he had been requested to read some notes with regard to it. It had been of good use, and did some very good work at Seaham Colliery after the explosion there. The apparatus is patented by Messrs. Forster and Fleuss, and consists of an arrangement by which the air is filtered, and after being purified with pure oxygen is taken into the lungs. A flexible mask covers the face, and tubes are provided for inhaling and exhaling the air. The lamps are self-contained and portable. They give a brilliant light for four hours, either in water, or in the most inflammable gas, without any chance of extinction or of

explosion. The apparatus had been successfully used at Burton-on-Trent, as well as in the Seaham Colliery. In the latter colliery the apparatus and lamp enabled the men employed to penetrate a considerable distance in advance—in one instance upwards of 300 yards—to examine the state of the roads, which were filled with gas. The men were frequently enabled to continue at work, in putting up the brattice, when it would have been totally impossible to do so if the ordinary safety lamp had been used. Usually the gas was taken from London, compressed in wrought iron bottles, but at Seaham there was so large a quantity required that it was made on the premises. The apparatus, in addition to being of use in mines, would be available in cases of fire on board ship, and for examining ship bunkers."

A fuller description, given by the inventors, may also be added:—

"The principle of the apparatus is that the wearer breathes his own breath over and over again—the carbonic acid being absorbed from it at each expiration, and the requisite amount of oxygen restored, the revivified breath is fit to be again inhaled in the form of pure air."

"The apparatus, which is carried upon the back of the diver or explorer, consists of a strong sheet copper cylinder, 12 inches by 6½ inches, with domed ends, and capable of holding four cubic feet of oxygen gas at a pressure of 16 atmospheres. Above the cylinder, and attached to the side of it, is a square metal box, 12 by 12 by 4 inches, to contain the carbonic acid filter, which is a box of vulcanite, divided into four compartments, and with a wooden lid made air-tight by an india-rubber washer, and having an inlet and an outlet tube; this box is filled with a packing of ordinary tow, interspersed with two pounds of stick caustic soda; the exhaled breath passes twice up and down through the interstices of the tow, by which it is finely divided and thoroughly freed of carbonic acid by the caustic soda, the excess of

moisture collecting under a perforated false bottom arranged for the purpose."

"A flat bag of vulcanized india-rubber is fastened to the apparatus, and is connected by an india-rubber pipe over the shoulder to the outlet pipe of the filter; the bag is also in communication with the oxygen chamber, and the supply of oxygen to the bag can be regulated by a jamb screw valve under the control of the wearer."

"An india-rubber mask is made to fit air-tight to the face, and is held in place by straps buckled up at the back of the head; the mask is fitted with a pair of flexible valved pipes, the one for exhaling being in communication with the inlet pipe of the filter, and the other for inhaling in communication with the air bag."

"The exhaled breath having passed through the filter enters the bag in a purified state, and there meeting with its complement of oxygen is fit to be again inhaled. The bag being perfectly flexible readily expands or contracts as the breath passes in or out of it, so that no effort is required in respiration."

In practice, it seems that this mask has been found painful, owing to the pressure of the bands upon the head, and that Denayrouze's is preferred.

"Foster and Fleuss's Patent Safety Mining Lamp is a modification of the lime light, methylated spirits of wine being used instead of hydrogen gas, and consists of a strong copper sphere, seven inches diameter, and capable of being charged with oxygen at a pressure of from 16 to 20 atmospheres. To the top of the sphere is attached a small spirit lamp, with two wicks, between which, through a small jet, a minute stream of oxygen, regulated by an adjusting valve on the sphere, is allowed to pass, carrying the flame against a cylinder of lime held on a stud placed to receive it."

"The light is covered in by a double dome-shaped metal casing, having an annular space left between its inner and

outer surfaces, which is filled with water; discs of plain glass are inserted opposite each other in the inner and outer casings, and a small outlet valve is fixed in the inner case, near its lower part, for the escape of the products of combustion, from the inside of the casing into the annular space filled with water between the two cases, through which the gases bubble and escape through another outlet valve fixed on the top of the outer case. The cover is attached to the lower part by means of a screw, an air-tight joint being made by a leather washer seating."

The inventors state that the apparatus "will supply breathable air for four hours at a time"; and that the lamp "will burn for four hours equally well under water, in carbonic acid, or in firedamp, and that it cannot get hotter than boiling water."

The Secretary of State has had his attention drawn to the Fleuss invention, and is anxious that the inspectors of mines should make it well known, and that the various colliery districts should participate in its advantages; and, as was proposed by Mr. T. Y. Hall with respect to his system, it is suggested that stations should be organised in mining districts, where the apparatus should be stored in sufficient numbers, and maintained in readiness for immediate use, and where the instruction of men from the surrounding coal mines in its use should be systematically carried out, in order that a rescuing party could thus be speedily on the spot after the occurrence of an accident.

The Diving Dress.

The ordinary diving dress, with divers from Liverpool, is occasionally used in this district, when pump valves have ceased to act, and access to them has been cut off by the rising water. This appliance, with the trained men, is usually successful for water, but it does not appear to have been much used for gases.

Other similar inventions might also be quoted, but these will suffice for the present.

Conclusion.

Those who have assisted in penetrating a mine after a great explosion, when the blast has scattered the means for ventilation, and access is only to be had amongst the *débris* and irrespirable gases, know what has to be encountered on such occasions. Rubbish has to be cleared through and bratticing hastily put up, by which a way is opened and fresh air carried forward. As this progresses, should the mine prove to be on fire, there is the often uncontrollable risk of gas, too pure to fire, being brought to an explosive mixture, and a repetition of the explosion ensuing. Even if the mine prove not to be on fire, there is the delay of clearing out the accumulations of afterdamp and other gas. As opening after opening is reached, there is the heart-breaking delay in advancing to the next, lest fellow-creatures may be living beyond to whom every moment may be vital. At such times the writer has always held that, although attended with some risk, side accumulations of gas may be passed by, and an air-current followed. But what would one not give at such a time for a respirator and a lamp by means of which the noxious gases could be safely penetrated, and more speedy means than bratticing air from opening to opening taken for the rescue.

Such inventions, as has been shown, have long been made known, through the medium of the inventors, the public prints, and otherwise, but they have not come into common use. Thirty-one years ago, the writer formed one of a party in re-opening a colliery, after an explosion and fire, when hand bags of Glauber salts and lime were used for breathing through, but they do not appear to have been much used since. Denayrouze's apparatus was brought to a serious case of fire, surrounded with fire-damp, in a colliery,

in North Wales, but neither the inventor's agent nor any one would trust it to descend the shaft amidst irrespirable gas, and the old fashioned means had to be used. Some better results have attended the Fleuss apparatus. But with it organization is requisite. Oxygen gas has to be provided, and men instructed in the use of the apparatus are requisite. The diving dress is acknowledged and practised, now and then, as stated, in pumping pits; and it was put on when upwards of 200 persons were shut up in the Hartley colliery by the breakage of the pumping engine beam, and has been proposed for other occasions, but without much useful effect, except for water.

The recommendations of the various systems is, therefore, now commended to the earnest consideration which this Society always gives to important mining subjects; and to the earnest consideration of the other colliery owners of this district who are not members of this Society.

The PRESIDENT said he believed it was intended, at a subsequent meeting, to exhibit the Fleuss apparatus, which Mr. Dickinson had described; and until then he thought they might advantageously defer the discussion.

ON THE MUESELER SAFETY LAMP AND TESTING APPARATUS AT CELYNEN COLLIERY.

Paper communicated at the February Meeting by Mr. Dickinson. Part V., Vol. XVII.

DISCUSSION.

Mr. TEALE said that the method of testing safety lamps had occupied his attention for many years. No one desired more than himself to see an effective system invented, for the reason that it would go a long way towards saving life in collieries. They were indebted to Mr. Dickinson for much information with regard to testing apparata. One

very interesting apparatus for testing lamps, and by which a defective lamp was occasionally detected, consisted simply of a circle of metal tubing, perforated. In the South Yorkshire district it engaged so much attention that a committee was formed for the purpose of inquiring as to its advantages. A number of lamps which were brought down were put to the test thoroughly. Unfortunately for the arrangement, whilst in some cases they could discover a defect in a lamp—(and all those tried were known to be defective)—in others the test would be applied a score of times before the defect showed itself. Mr. Green's test was a simple arrangement, and one that had been known for a number of years. In testing lamps, however, there was such a variety of results produced from the same lamps, and also from the same tests, that there was no certainty, when you tested a lamp in a defective condition, that the lamp will show itself to be defective. With regard to this particular apparatus, he had had a good deal of conversation with Mr. Green, and they differed very considerably as to its advantages. For his own part he (Mr. Teale) considered it would be a great disadvantage to adopt any such system, because the men in charge of the lamps would look upon it as a means of removing all responsibility from themselves. If a lamp passed the test, it would be handed to the miner, though it might be positively unsafe, and the man would take it down the pit in that condition. As a proof of this, he might mention that at the Celynen Colliery he took a couple of lamps and damaged them seriously, and then handed them to the lamp man in charge, to be subjected to the test. Both lamps were put into the box together, and both went out. They were also put in separately, and in all cases the effect was merely to extinguish the light without exposing the defect in the lamp. His contention was that this was a case in which the lamps would probably have passed the inspection of the lamp man, and they might have been taken into the pit,

and, in certain circumstances, have caused an explosion. He did not think it sufficient, as had been contended in this Society and elsewhere, to say that at all events it was some satisfaction to a collier to know that his lamp had been tested. The testing apparatus had, to his mind, one or two serious defects: he referred more particularly to the range of velocity of the air current. This was produced by the turning of a fan. They all knew that a difference in the quantity of air, mixed with a certain proportion of gas, produced different results. Then there was no means of fairly testing the lamps simultaneously, owing to the presence in the chamber of carbonic acid gas. It was absolutely necessary, at each test, that the box should be cleared of carbonic acid gas, or they would, under apparently the same circumstances, get very different results. For that reason he held the arrangement to be crude and unsatisfactory. It would show certain defects with a safety lamp, but was by no means a test, in the proper acceptation of the term. With regard to the exact proportions of the lamp, he also differed from Mr. Green. In the Belgian experiments with the Mueseler lamp it was said that a too great lowering of the chimney on the flame was injurious. They certainly adopted an arrangement of lamp different to what was expressed in that respect. He had found that the lowering of the chimney below the horizontal gauze was a very great defect, and for this reason: the glass might be termed a combustion chamber, and the action which took place after an explosion in a lamp was this: the flame was forced, by the production of carbonic acid gas, from the wick; it rapidly filled that combustion chamber, and, as soon as it had risen to the top of the glass, underneath the horizontal gauze, the light was extinguished. The fluctuation of light, which continued in the form of a small bead of blue flame, would ultimately, if maintained, produce a temperature sufficient to overcome the influence of the horizontal gauze,

and this would be carried into the upper part of the lamp. When that occurred it was, in his opinion, far more dangerous than the Davy lamp. Therefore, in his opinion, the chimney ought not to be brought lower than to allow the necessary flange to attach the horizontal gauze. The method adopted by Mr. Green of putting in a fly, or stop (there might be one or more), was likely to be attended with advantage, especially if more than one were used. He also thought, with regard to the shield, that this was, to some extent, also an advantage, for the reason that it did not affect the combustion of the gas below the horizontal gauze by direct action upon it; at the same time, the more that the shield was carried up, the more it interfered with the ventilation of the lamp. This arrangement would not prevent an explosion in the Mueseler under what was known as an eddying or whirling current—that was when the air and gas travelled down one side and up the other—because, if the combustion chamber could only be cleared of carbonic acid gas sufficiently to maintain combustion, there must come a time when the temperature would be raised to a point sufficient to cause an explosion. In the discussion at the former meeting, Mr. Woodward spoke of the double gauze, and asked whether that would prevent the movement of the small bead of flame after the lamp had gone out. Certainly it would not. It was no advantage at all. The double gauze, in many respects, was a disadvantage. He endorsed Mr. Wild's remark about the chimney being too short.

Mr. Purdy (Notts) (through the Honorary Secretary), said that he considered Mr. Green's addition of a shield, 2-in. in depth, around the lamp, closely approaches the principle with which he (Mr. Purdy) considered perfection may be arrived at. In the discussion after the paper was read Mr. Woodward referred to a double gauze, slightly separated by a brass ring, for the purpose of preventing gas burning within the

lamp after the flame of the wick is extinguished. From his experience with the Mueseler lamp, he should say that the double gauze would limit the passage of air too much, and consequently diminish the power of the light. With regard to the gas burning in the lamp under the gauze after it leaves the wick, this would very much depend on the power of the air current impinging against the lamp. He agreed with Mr. Williamson that the Davy, although it is far from being absolutely safe, has been a good and useful lamp, and that many explosions are due more to the faulty construction—through the use of bad material, inefficient labour, and a desire to place a cheap article in the market—than to the principle of the lamp itself. The flimsy construction of lamps is a matter of such immense importance that it should have the attention of our legislators. There is, in this country, no standard of any kind except for the gauze, and even that is not always attended to.

Mr. James Ashworth (through the Hon. Secretary), said, on page 70 Mr. Green says that his improvements to the lamp render it unexplodable under all probable conditions, but unfortunately he does not go on to state what tests the lamp has been submitted to. Mr. Green's lamp in the shield improvement closely resembles the Mueseler Thonard tested by the Belgian Commission, which proved unexplodable in 14 experiments made in velocities ranging from 6·560 to 13·12 feet, but out of 64 experiments in a velocity of 19·68 feet, three explosions, and three cases of simple passage of the flame into the gauze cylinder occurred. The commissioners further remarked that "the Mueseler lamp furnishes a much "greater number of cases of complete extinctions than the "Thonard lamp, but in the latter the combustion of the gas "under the wire gauze is most active. In fact, out of 64 "experiments at a velocity of 19·680 feet, the latter lamp "was only 8 (eight) times completely extinguished."

Mr. Green's projection under the horizontal gauze might of course cause complete extinctions in the Thonard as in his own tests, but the whirling motion of the ignited gas under the disc gauze must be caused by the outer shield, corresponding with the whirling motion of the flame of a Clanny lamp, as I do not remember ever seeing the motion under the disc of an ordinary Mueseler.

The shield for the disc gauze, described in my paper on an improved Mueseler lamp (See Part xvii., Vol. xvi.), was designed to meet the same risks as Mr. Green's, but at the time I designed it I was of opinion that the passage of the flame through the disc gauze arose from the fact that the gauze on the return side of the chimney became an upcast to carry off the products of combustion which could not escape up the chimney and out at the limited outlet of 10 millimetres, and became heated at this point until the flame readily passed through into the gauze cylinder. The most dangerous point being close to the chimney on the return side.

With the addition of my shield and chimney pot (See Part xvii., Vol. xvi.), I never succeeded in getting an ignition under the disc gauze.

Mr. Green's shield offers no protection to the top of the chimney. I have, as a suggestion of a practical character, forwarded for inspection the top of my new lamp, in which the cylindrical gauze, chimney, and horizontal gauze, are completely protected from the effects of any velocity of current.

Mr. Dickinson said: The communications which have been laid before this Society are entitled to our serious consideration. In the first place we have, in Mr. Teale, I would say, by far the largest manufacturer of safety lamps in this part of the country, and his lamps are used in many collieries in this district. He must certainly have the utmost anxiety to have his lamps of the most perfect kind,

and to have them subjected to such tests as will ensure their being considered safe to use. I wish we had had Mr. Green here himself to have answered Mr. Teale, for from what you have heard, you may take it that Mr. Teale is one of those persons who, in Mr. Green's opinion, are undoubtedly wrong in their assertion that the practice of testing safety lamps at bank in an explosive mixture of gas and air, is useless. Mr. Green holds exactly the opposite view. His opinion, moreover, is in accordance with the memorial which was addressed by the working miners of Great Britain, two years ago, to the Home Secretary, in which they wished it to be made compulsory, that all safety lamps should be subjected to such a test. Then, as regards Mr. Ashworth's lamp, I wish we could have seen it complete. As it is here, having no glass, there is no means of testing how it would burn. Mr. Ashworth's opinion is, nevertheless, entitled to very great respect. He took a very important part in the experiments at the Bryn colliery, with Mr. Smethurst, and was one of the authors, along with the last named gentleman, of the papers on testing, which were laid before this Society two or three years ago. The result of those experiments is, that Mr. Ashworth has produced the lamp which he has sent us here to-day; a lamp which has got a tight-fitting copper cap, covering the whole of the upper gauze. How this lamp will burn I do not know, that would have to be tested; but Mr. Smethurst has produced a lamp almost identical with this of Mr. Ashworth's, except that, in Mr. Smethurst's, the cap is moveable, it can be lifted on and off, so that the gauze and top can be seen, and you can tell whether there is any deposit of soot or not. The burning of this lamp I have tried. On Saturday last I took Mr. Smethurst's lamp down a colliery, where it was exposed to currents from the highest to the lowest velocity, and the burning was not at all interfered with. I carried it about two miles, and part of the way was an inclination of one in

four; I also carried it over the surface when the wind was blowing strong, that day, and then I took it down another shaft. The lamp continued to burn well. Thinking that the cup was rather too small to hold sufficient oil for a long shift, I kept the lamp burning during the day, and found that it burned twelve and a half hours before going out. It burned brightly the whole of the time. The only objection I found to it was a trivial and easily remedied one, viz.:—that the wire forming the handle was too thin, as it hurt the hand when carried about for a few hours; with that exception I could find no fault with the lamp. In carrying this lamp of Mr. Smethurst's, with the cap covering the whole of the top gauze, I found that it got scarcely any warmer than the Clanny lamp, perhaps it was a shade warmer, but not so much so as to be objectionable. But when left standing, it got so warm as to be very perceptible to the touch, and a little unpleasant, but that is the state in which lamps would be when the miner has to use them, for he is generally stationary, and is not in the full draught of the principal galleries. Mr. Smethurst's and Mr. Ashworth's lamp are each Mueseler's, but whether the caps make the lamp quite safe in explosive currents I have not tried. Then, with respect to Mr. Purdy's communication—he is a gentleman who has given great attention to the subject, he has written a pamphlet, and gone carefully into the matter; therefore, I hope the observations made will be considered and criticised only with the object of bringing what is good out of them, and not in any captious spirit.

Mr. Martin said as to the application of a test leading to lamps being passed unexamined, that kind of argument had often been used with reference to improvements. He had used it himself, and had heard it used, about safety catches and detaching hooks many years ago, but there was no reason why the supervision need be less careful

because a test was applied, than it was when there was no such test. Of course, if the test superseded the examination, it would be objectionable and probably delusive. It might as well be said that the use of lamps was to supersede ventilation. The one argument would be the same as the other.

Mr. Teale: I think you hardly take in my meaning. They are both there, not as a matter of necessity, but as a means, under certain circumstances, of preventing accidents. I should be one of the last to say that lamps should not be properly examined, and still further, that they should not be tested; but the tests applied should be effectual. I am quite certain there is no test at the present time which can be considered perfectly safe and reliable. The best way is to have the lamps so constructed that all parts can be examined on the surface, or as it passes the deputies down below. In the North of England they have an admirable system: each deputy examines for his own district, and has not more lamps to go through than he can properly examine.

Mr. Martin: I quite endorse Mr. Teale's view—each fireman, or deputy—as he is called in the North of England—should examine the lamps in his own district. He should examine them thoroughly, and be made responsible for them. But I fail to see that the examination need be less stringent because the lamps are also tested in inflammable gas.

INTERESTING SECTIONS OF STRATA AT READYCON DEAN, SADDLEWORTH.

By William Watts, F.G.S.

On the 6th of June, 1882, I had the honour of reading to the members of the Manchester Geological Society a short communication "On a Section of Coal Measures in Saddleworth."

In that communication I expressed an opinion that the exposed measures on the upper reaches of Readycon Dean Valley belonged to the Yoredale series. I still hold that opinion, although Professor Hull has figured them in his interesting "Geological Memoirs of the Country around Oldham" as millstone grit.

Since my last communication to the Society on the subject referred to, I have extended my observations, and regard this communication as supplementary to the one which I had the privilege of reading on June 6th of last year.

For the Yoredale character of the measures in this valley I rely as much on the evidence afforded by some of the fossils produced as on the character of the deposits in general, although I am aware there is a general blending of the two where the zones meet, or line of demarcation effected.

The lower deposits nearly always crop out on the higher parts of our hills, and judging from the large number of subangular millstone grit blocks which I have found buried in the valley alluvium, and others which remain exposed in the brook course, I am persuaded that they are the remains of ancient millstone grit cliffs which have fallen back on the demands of time and atmospheric agencies. No crags now remain in the valley to bear witness to this condition, and whether, on looking up or down the valley, we see undulating, rounded slopes, covered with scanty vegetation. Trees there are none, although in the peat and beds of clay which nestle in sheltered places 15 to 20 feet above the brook course, numerous rootlets and stems have been found during our excavations, mainly of birch and hazel. Tree life, however, in former time grew more dwarfish and scanty on the higher reaches than lower down the valleys; but why trees do not live on the higher zones of our hills at the present is a question for the botanist, and not for the geologist, to determine.

Whether the climatic conditions are too severe, or that the soil in which the trees lived has been washed down the valley, are debatable questions. It may be that tree life, like some other vegetable forms, exterminate themselves by profuse growth and length of time, and thus give way to other forms better fitted to the changed conditions.

I conclude, therefore, that the sections made in the valley for the Readycon Dean embankment are in the Yoredale series, whatever may exist on the hill tops underneath the thick covering of peat and alluvium.

About half a mile from the embankment, and 150 feet lower in altitude, we have worked a quarry, which shows striated rock-faces beautifully. This polishing and horizontal striation are caused, in my opinion, by grains of sand and other earthy matter having been carried in suspension of water and impinging on the rock-faces as the surface water coursed its subterranean channels to emerge again on the surface as spring water. These planes of jointage are never wide apart, and are invariably free from *debris*. Such, is the result of my experience, which has been mainly confined to the southerly slopes of the Pennine range at the sources of the Tame. Where the joints are tolerably close, and below the surface of the adjacent ravines and brook-courses, they are frequently filled with fine impalpable mud, which has been carried from the surface; but, owing to the circuitous routes, which the water has been forced to follow, its flow has been checked, and matter in suspension has had time to settle, and thus the spring has been clear and sparkling on gaining the surface.

It is impossible for water to enter the joints of rock at the surface in a turbid state and come out clear without leaving matter behind which must find rest somewhere. I have seen innumerable joints so filled; some quite hard and dry and some wet and soft within a few feet of each

other. This is what we may expect, and what would in time occur, in an artificial filter, if not periodically cleansed.

These observations apply to planes of jointage near to the surface only, or at least when the member communicates with the surface. Should a hard, band of shale intervene unbroken on its bed, and through which the surface water cannot pass, it is thrown out at the top; consequently the bed of rock beneath frequently presents clean joints free of water. If the rock be basin-shaped, having no opening into ravines, the conditions here alluded to may be modified, and water may or may not be retained in the crevices under such circumstances. Water is seldom permanently retained in massive rock. It varies, however, in quantity, according to the number and size of the joints, geological horizon, and amount of rainfall. Rock permanently soaked in water is generally laminated, close jointed, fine textured, and large on the bed. It is not favourable as a building stone for retaining colour. Such is the result of my experience of water-soaked rock in the neighbourhood of Manchester.

Although water clears itself of suspended matter in passing through crevices and chinks in rock, owing to its solvent properties it hardens on the way by dissolving rock constituents, and thus tends to enlarge the joints and chinks traversed, where the flow is excessive. The beds are not attacked, because there is no circulation of water on them; hence movement is necessary to produce friction and absorption in the case of water.

Owing to extensive shale beds covering like a blanket the whole of Readycon Dean Valley, few springs exist in it, and those are very small, and soon dry up in fine weather. Natural agencies in such a place do not assist the water-works engineers to empound the rainfall by retaining it in the rocks; and I hold the opinion that compensation water given out to satisfy the stream where a system of

reservoirs is established for a town supply should not be based on the average rainfall, but on the amount of water which can be retained after loss by floods and percolation. Many towns, I know, suffer in this respect.

The subject is an important one, but it is scarcely a subject for this Society to take up. It would lead to the consideration of the configuration of a drainage area; the power of rocks to retain water and otherwise. On the face of it, it seems anomalous that a corporate body should be compelled to give riparian owners about one-third of the average rainfall from a district which will not admit of reservoirs being made large enough to control a steep and impermeable drainage, and claim the same satisfaction from a wide and flat valley, whose upper limits or drainage are covered with retentive rocks feeding a large number of springs all the year round. It is nearly as bad as a landed proprietor putting a money value on aspect, sunshine, and rainfall when his land is wanted for waterworks purposes.

Having dealt with the general features of the district, and incidentally alluded to pluvial agencies to illustrate my remarks, I will now pass on to consider the interesting sections produced which were exposed on the site of the reservoir whilst excavating for the embankment now nearly finished.

Sections numbered 1, 2, and 3 have nothing particularly interesting about them, but they strikingly illustrate the typical kind of material to be seen on the slopes of high moorland. The whole of the sections are 1250 feet above the sea level. Section numbered 1 is intended to show the covering of peat at the top which is usually found on sloping ground in moist situations. The rate of growth is not known, although I do not see any great difficulty in ascertaining it if typical places could be selected, and sufficient time allowed for the observation. In the year 1868 I discovered a layer of peat 18 inches in thickness,

which had been deposited on an old waggon road in the Swineshaw Valley, near Stalybridge, which had taken about 60 years to deposit. At the top end of the valley a millowner's reservoir had been constructed, and it was on one of the old waggon roads the discovery was made, which an old inhabitant informed me was built about 60 years ago. This is the nearest authentic record I have of peat growth, but it must be admitted that it is approximate only, and perhaps laid down under the most favourable circumstances. Peat is essentially a vegetable mould, and although agreeing in colour, it is unlike the soil of our fields, which has many times passed through the bodies of worms, as demonstrated by Darwin. Moles do not burrow in peat, and worms cannot live in it, and this vegetation reigns supreme on the accumulated products of its dead ancestors. Tough clumps of wiry grass rise at short distances on the swampy morass, as if designed to check the rainfall, leaving the surface of the marsh, and thus converting the whole into tiny lakes, surrounded by miniature islands. I never cross a peat bog without picturing to myself the formation of ravines determined at the outset by tufts of wiry grass directing rain water in one direction in preference to another.

In excavating for road macadam for the repair of the New Hey and Huddersfield Turnpike, at Rag Stones, the workmen, on removing a covering of peat varying from two to three feet, came upon a floor of loose millstone grit cobbles, suitable either for fence walls or road ballast. These unconformable rocky fragments had all their fractured edges worn off either by exposure to atmospheric agencies or to the action of the waves during the slow uprising of the Pennine range out of the sea, or other cause. They could scarcely be called subangular blocks, as the edges were not worn enough for this name to be applied to them. The interstices were free from silty or other matter,

and, like all coarse gritstone underneath peat, they were bleached white; the acid from the peat having decomposed the small amount of iron in the stone, which gives it the grey tint so common in millstone grit. The layer of stone was about three feet in thickness, which doubtlessly had fallen into a sunken patch of ground which held water like a basin, barely covering the stones and allowing the peat to grow as long as it could, life ceasing when the water was drained away. The peat covering would be the last stage in the phenomena alluded to, and young compared with the paved flooring. What struck me when I examined it was the unusual circumstance of peat being found on dry stones; hence I record the fact for what it is worth. A large fault exists hard by, and it may have had something to do with the matter.

The scenery here is wild and picturesque, and attains an altitude of about 1,300 feet above the sea level. The upper limits of the Tame drainage are reached. A circuitous brooklet leads you into a narrow but deep ravine, carved in black shale in the form of the letter V. In this narrow gorge you are secluded from the surrounding moorland landscape. You see nothing but the water at your feet, the sky above, and black barren walls of shale on each side. In certain places the depth is not less than 30 feet.

Referring to Section No. 5 on the diagram, a black silty vein of carbonaceous matter appears broad at the bottom and pointed at the top, and which scarcely pierces the stratum in which it is fixed. The section is singular on this account, and whether its structure is owing to a land-slip or small fault I cannot tell. The matrix was very soft, and enabled me with ease to push my stick several inches into it. The shale on each side of this fault is somewhat contorted, and tinged with ferruginous matter. I have drawn the section to a natural scale, and imitated nature as

faithfully as I could. Indeed, the same remark applies to all the other sections.

Section 4 is a very interesting one. It represents a dyke of clay fed from above and out into the shale beneath. Whether it has some connection with Section 5 on the opposite side of the valley, and at about the same angle to the brook course, I cannot say. It is wider at the top than at the bottom, and goes below the floor of the tramway, which is represented by the bottom of the section. The clay is slightly mottled, with a sprinkling of small stones of similar grit to the rock of the district, and a short distance beyond the limits of my section small rootlets and tree branches were dug out of the same bed of alluvial clay. All the pockets of clay reposing on these hill sides represents so many small dams, which received the waters of the district at a period before the valley was so wide and deep as at present, or else it is, as I sometimes think, produced by vegetable organisms decomposed in water.

Section No. 6 I call the goniatities and crustacean beds. These beds are composed of black carbonaceous shales, which have been considerably disturbed from their normal position, since deposition and hardening. They are in close proximity to a large fault which throws up inferior measures, of which the black band indicated on the section probably is a member. The dip of this band is at an angle of 65° or thereabout.

At each end of the section, which is 72ft. in length, nearly horizontal beds appear, less dark in colour, but equally friable on exposure to atmospheric agencies, especially to frost and rain. The depth of the section is 7ft., but a few feet of the top had been removed before the discovery was made that it contained fossils, or that unusual blending of beds existed beneath.

Nodules were found in the black upturned bands, as well as in the horizontal layers at each end, in about equal num-

bers, but I am not prepared to say in which the different species on the table existed, as I did not open my specimens on the ground, but at home at my leisure and after they had dried.

All the nodules found are small, rarely reaching two inches in diameter. The greatest number is goniatites, next indefinite specimens of what I consider to be leaves or other vegetable matter. Two specimens of calamites with spicule at the nodes were found in a good state of preservation, but now have almost disappeared, owing to my having sent them to friends for inspection.

The most important "finds," however, are two specimens of crustacean remains, which I have not been able to identify, but trust to be helped out of my difficulty by members present.

The largest goniatite on the table is *Goniatite Listerii*, which was found near to my section by a friend who is always watchful in his quiet walks in these lonely dells for objects of interest to the geological student.

Tolerably large specimens of the orthoceras have been found in the valley, also aviculopectens inside nodules as well as in the shales, but not in the material composing my section.

A short distance above the excavations now being carried on, bare patches of sloping land furnish flint chippings to the collector, of the form on the table, and three old horse-shoes have been found in our clay and peat beds; and I picked up out of the alluvium this large quartz pebble, which is a rare specimen to find so high above the sea level on the Pennine range.

I do not think there is great antiquity belonging to the horse shoes. Doubtlessly they belong to a much later date than the Roman occupation, but they are interesting "finds," and deserve recording.

Section No. 7 is interesting only on account of the changeable nature of the deposits in so short a distance, together

with the dip of the beds. It is evident that fierce disturbing agencies have been at work here in remote time to tilt up the strata as we find them.

The rocks and shales of the district have a decided Yoredale aspect, to which series I believe they belong in part, if not wholly. I do not altogether rely on the lithological character of the beds for my correlation. The fossils produced assist me in that determination, although I am aware that similar species are found in the millstone grits, with the exception of, if I mistake not, the crustacean nodule*.

The PRESIDENT said: I should like to ask Mr. Watts if he has given attention to the question of whether these smooth and scratched surfaces which he has described may not be slickensides? I fail to see that little grains of sand washed down into the crevice of the rock could have produced them, particularly as the crevices were (according to the description) narrow, and usually filled, sometimes with soft and sometimes with dry material. I am acquainted with many places in the Pennine chain—notably in the Cliviger Valley, and near the source of the River Hebden—where beautiful slickensides occur in the millstone grit rocks. These sometimes present very beautifully polished surfaces, and a certain amount of heat seems to have been generated by the friction of the rubbing surfaces. It is not unlikely, I think, unless Mr. Watts has other reasons to assign, that the examples alluded to in the paper partake of this character. The finding of remains of vegetation—trunks and branches of trees—beneath the peat, at an elevation of 1,300 feet above the sea level, is by no means unusual. They occur on the moors about Bacup, and on the high lands constituting the watershed, between

* The President is not sure the remains are crustacean, although he cannot name them.

the East and West, above Todmorden. They there lie at the base of the peat—sometimes large trunks—and one could hardly dig into the peat without finding sticks and small branches, and also what is most peculiar, the bark of birch trees, which is preserved, while the wood itself has decayed and disappeared. I have myself described them on more than one occasion, and the late Mr. Stansfield, of Todmorden, described their presence at an elevation of 1,300 feet. The fact, stated by Mr. Watts, of the interstices between the stones which underlay the peat beds not being filled with any kind of material, is certainly remarkable.

Mr. DICKINSON said he was struck with the account given by Mr. Watts of the colouring matter having been taken out of the stones which underlay the peat. Many times, noticing the floors of peat beds, he had seen that almost the entire colouring matter had been extracted, as if the peat had fed upon it, and had left it in the form of a white clay. He thought there must be some impervious stratum intervening between the clay and the stones which had been referred to, preventing the water from getting down, or the interstices would have been filled with peat.

The PRESIDENT said the circumstance mentioned by Mr. Dickinson was remarkable. He had observed, at Brandwood Moor, beds of a white unctuous matter at the base of the peat. It seemed more like pipe-clay than anything else. It was a singular fact that, whilst peat itself contained a great deal of colouring matter, many of the stones found embedded in it should have quite a bleached appearance. One could scarcely understand the *rationale* of this. Instead of the colouring matter being extracted from the stone by peat, they would rather have expected a contrary effect.

Mr. MARTIN said that Mr. Watts had referred to a certain bed of peat, 18 inches or 2ft. thick, which, he calculated, had occupied about 60 years in deposition. He would

like to ask Mr. Watts upon what facts this calculation was based.

Mr. STIRRUP said, with regard to the existence of peat on high moorlands, he thought there was no doubt it was a proof that in former times—how far back could scarcely be determined—forests existed there. It had been asserted that the Romans cut down those forests. If that were so it must have altered the climate somewhat; and the districts thus denuded of wood had not been, and perhaps could not now be, replanted. It would be interesting to know if attempts had, at any time, been made in that direction, and with what result. In France large tracts of country, which before were barren, were being planted with trees.

Mr. WATTS said with reference to the President's observations, that he was anxious to persuade himself that the appearances he observed upon the rock surfaces were the result of slickensides. That, however, was impossible. The beds were uplifted, though not at a high angle, and the markings to which we alluded were horizontal. They were certainly remarkable, and he could only account for them in the way suggested in the paper. With reference to peat covering the stone, it might be that some part of the upper stones would have silted material in the interstices; but certainly the bottom and middle part of the stone flooring were free from any material. It was a remarkable circumstance, and one that surprised him very much, hence his allusion to it in the paper. As to the bleaching of the stone, he thought it was a fact that stone, in proximity to the coal measures, was nearly always more highly bleached than stone separated from the coal measures. As to the data upon which he founded his estimate of the age of the peat beds. He got his information from old residents in the district, but he had no written record of the making of that small mill owner's dam. In making their large embankment, the smaller one, which was made, as he was told,

sixty years ago was enclosed. That was probably not far from the mark, because the old people seemed to be pretty well agreed as to the time when it was made. The peat was along the wagon roads, easily traced; in fact, in one or two places he found an old sleeper, and it might, by the conditions of growth, in that position, were more favourable than the general conditions of peat life.

The PRESIDENT: Possibly some may have been washed down by the rains, from above.

Mr. WATTS said it might have been. He quite agreed with Mr. Stirrup as to the propriety of planting the high moorlands with trees, if suitable species could be found. He was of opinion that if corporate bodies, who owned drainage areas in the upper reaches of the Pennine Chain, and similar districts, would do so, it would be a source of profit to them, and he should be glad to see the experiment tried.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XVII. SESSION 1882-83.

The ORDINARY MEETING of the Members of the Society was held on Friday, the 4th day of May, 1883, at the Mining School, Wigan;

WALTER TOPPING Esq., M.E., in the Chair.

The following are the recent additions to the Library :—

Belfast Natural History and Philosophical Society: Proceedings for Session 1881-82; *From the Society.* Birmingham Free Library: Report for 1881-82. Catalogue of Works on Natural History, including many relating to Geology. Catalogue of Periodicals, Journals, and Transactions of Learned Societies, and Issues from H.M. Government and Private Presses. (Both Catalogues possess Index for the facility of reference.) *Presented by Mr. Bernard Quaritch.* Cambridge University: Report for 1882. Cornwall—Royal Institution of: Journal, Part 3, Vol. VII., December, 1882; *From the Council.* Devon and Exeter: Free Library 13th Annual Report April 14th, 1883. Dublin: Royal Dublin Society—Transactions, Vol. I., Parts 15 and 16; Proceedings, Vol. III., Part 5; *From the Society.* Dundee: Free Library Report, November, 1882. Edinburgh Geological Society: Transactions for 1881-82; *From the Society.* Edinburgh Royal Physical Society: Proceedings, Session 1881-82; *From the Society.* Glasgow Natural History Society: Proceedings, Parts 1-2, Vol. I.; Part 1, Vol. V.; *From the Society.* Geology, Text Book of: by Dr. A. Geikie; 1882; *Purchased.* Hull, Prof. E., F.R.S.: Contributions to the Physical History of the British Isles; *Presented by the Author.* Three Geological Pamphlets, by Professor E. Hull, F.R.S.; *Presented by the Author.* Institution of Mechanical Engineers: Proceedings, No. 4, 1882, No. 1, 1883; *From the Council.* Iron and Steel Institute: Journal, No. 2, 1882; *From the Institute.* Kinahan, G. H.: Two Geological Pamphlets; *From the Author.* Liverpool

Geological Society: Proceedings, 1881-82; *From the Society.* Liverpool Public Free Library: 13th Annual Report, 1883. London; Geological Magazine, Nos. 224-7, Vol. X.; *Purchased.* London Geological Society: Quarterly Journal, Nos. 153-154, Vol. XXXIX.; *From the Society.* London Geologists' Association: Proceedings, No. 7, Vol. VII.; No. 1, Vol. VIII.; Annual Report for 1883; *From the Council.* London—Royal Institution: Proceedings, Part 1, Vol. X., (No. 75); *From the Institution.* London—Royal Society; Proceedings, Parts 222-4, Vol. XXXIV.; *From the Society.* Manchester Scientific Students' Association: Report and Proceedings for 1882; *From the Association.* Midland Institute of Engineers: Transactions, Parts 63-64, Vol. VIII.; *From the Council.* Mining Institute of Scotland: Transactions, Parts 10-12, Vol. IV.; Part 1, Vol. V.; *From the Council.* The Carboniferous Limestone and Cefn-y-Fedw Sandstone, North Wales; by G. H. Morton, F.G.S.: *Presented by the Author.* North of England Institute of Mining and Mechanical Engineers: Transactions, Parts 3-4, Vol. XXXII.; *From the Council.* Norwich Geological Society: Proceedings, Parts 1, 2, 4, 5, 6, 7,—6 Parts; (Part 3 out of print), 1878-83; *From the Society.* South Wales Institute of Engineers, Swansea: Proceedings, No. 3, Vol. XIII.; *From the Institute.* Volcanoes, by J. W. Judd, F.R.S., 1882; *Purchased.* Wigan Free Library: 5th Annual Report, January 20th, 1883. Yorkshire Geological and Polytechnic Society: Proceedings, Part 1, Vol. VIII., 1882; *From the Society.* America.—Agassiz, Alexander, Museum of Comparative Zoölogy, Cambridge, U.S.A.: Annual Report of the Curator, 1881-82; Bulletin, Parts 2-4. Vol. X. Cambridge: Science, No. 1, Vol. I. New York, American Museum of Natural History: Bulletin, No. 4; 14th Annual Report, May, 1883; *From the Committee.* Transactions of the American Institute of Mining Engineers, Vol. X., 1882; *From the Council.* Winchell, N. H., State Geologist: Geological and Natural History Survey of Minnesota; 9th Annual Report, 1880. Nova Scotia.—Halifax, Institute of Natural Science: Proceedings and Transactions, Part 4, Vol. V., 1881-82; *From the Institute.* Canada.—Toronto, The Canadian Institute: Proceedings, Part 3, Vol. I.; *From the Council.* Australia: Quarterly Reports of the Mining Surveyors and Registrars, Victoria; September to December, 1882. Foreign.—Académie Impérial de St. Pétersburg: Mémoires, Tome XXX., Nos. 9-11; Bulletin, Tome XXVIII.; *From the Académie.* R. Accademia dei Lincei: Transunti, Vol. VII., Fas. 2° to 10° inclusive, 1882-83; Memoirs, Vol. IX.-X., 1881; *From the Academy.* Deutsche Geologische Gesellschaft: Zeitschrift, Heft 4, Band XXXIV.; *From the Society.* Naturforschenden Gesellschaft zu Leipzig: Sitzungsberichte, 1882, *From the Council.* Naturwissenschaftlichen Gesellschaft Isis in Dresden: Sitzungsberichte, July to December, 1882; *From the Society.* Rio de

Janeiro: Museu Nacional Archivos. Parts 1-4, Vol. IV., 1879; Parts 1-4, Vol. V., 1880; *From the Council.* Società Toscana de Scienze Naturali Memorie Pisa: Fas. 2, Vol. V.; *From the Society.* Société Royale Malacologique de Belgique: Extrait, 3 Parts, 1882-83; Two Pamphlets, by M. A. Ruhot; *From the Society.* Société Vaudois des Sciences Naturelles, Lausanne: Bulletin, No. 88, XVIII, 1882; *From the Society.* Société Géologique du Nord, Lille: Annales, Tome IX., 1881-82; *From the Society.* Verein für Erdkunde zü Halle a/s: Mittheilungen für 1882; *From the Society.*

Owing to unavoidable circumstances, and at the suggestion of the Chairman, the discussion on "The Mueseler Safety Lamp and Testing Apparatus at Celynen Colliery," was postponed to a future meeting.

It was announced that Messrs. Fleuss, Duff and Company, at the next meeting, will be prepared to bring down to Manchester and show their Breathing Apparatus, duly charged and in working order, which will be fully explained and described by a representative of their firm, to the Members of this Society.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL. XVII. SESSION 1882-83.

At the last ORDINARY MEETING of the Session, held on Tuesday, the 5th day of June, 1883, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., J.P., President,
in the Chair.

THE FLEUSS' BREATHING APPARATUS AND LAMP.

Mr. BROWN, as representing Messrs. Fleuss, Duff, & Co., of London, attended for the purpose of exhibiting in working order, and of explaining, their Breathing Apparatus and Lamp for penetrating noxious and inflammable gases, as used in the re-opening the Seaham Colliery after the explosion in 1880. (See sketch.)

Mr. J. S. MARTIN read the description of Fluess's Apparatus, which formed part of Mr. Dickinson's paper, communicated to the Society at a previous meeting. (See *Transactions*, page 102 of this Vol.) In order to show the method of working, Mr. Brown invested himself with the apparatus, and demonstrated the possibility of life being sustained, by its use, in any poisonous atmosphere. In answer to questions, Mr. BROWN said that he wore the apparatus for thirty-seven minutes at a trial in America, in a chamber filled with dense smoke. This was a test before the Fire Department of New York. The mask—at first uncomfortably tight—got easier as his face warmed, and he began to perspire. He also said, with a proper and judicious use of oxygen, life could be sustained in a noxious atmosphere for four hours, with a man who knows how to use it properly.

Mr. WELLS then tried the apparatus; and afterwards, in reply to the President, stated that he had not felt the

slightest difficulty in breathing. Of course there was some difficulty in speaking, with the mask over the mouth, but he could hear the conversation in the room quite distinctly.

Mr. MARTIN then read the description given of the Lamp—(see page 103)—and the PRESIDENT asked Mr. Brown for information as to the cost of the Breathing Apparatus and Lamp separately.

Mr. BROWN said they were making the Breathing Apparatus, with a bottle of oxygen and all needful accessories, for £25; and the Lamp for £13 10s. The cost of an oxygen bottle, fully charged, was £4,—that being equivalent to between four and five charges of the Breathing Apparatus; but the bottle could be re-filled, when necessary, at a cost of 15s.

The PRESIDENT: I think Mr. Brown has explained, so far as he has gone, everything clearly and satisfactorily. Perhaps some member would desire further information or to offer some remarks, upon the apparatus and lamp as now exhibited.

Mr. DICKINSON: I think, gentlemen, I had my say in the paper read to you at a former meeting; but if it will open up the subject for discussion, I shall be glad to say a few words at the present time. In my paper I named the principal respirators that have been before the public since that of Dr. Hutchinson in 1849; I alluded slightly to their construction; and it would seem, from what I have seen of the Fleuss's Apparatus to-day, that the mask is pretty much the same as that used in connection with former apparatus. The valves, I see, are somewhat different in the Fleuss from those in the Denayrouze; and, as far as I have been able to judge, to-day, this valve is better than the Denayrouze valve. In fact, the valves in the Denayrouze Apparatus appear so liable to stick, that at one mine at

which I was present, in North Wales, where a fire had broken out and was shut off, and fire-damp was issuing from the mouth of the pit, Denayrouze's own agent refused to enter the pit with it. He would not trust the valves and fittings, and no other person would trust them. The Fluess's Apparatus, however, seem to work satisfactorily. The great difference between this invention and the others, as it occurs to me, is that oxygen gas is used here as the means of inspiring, and caustic soda is used for absorbing the carbonic acid of the breath. I should like to ask Mr. Brown whether any other caustic would answer equally well—say caustic lime?

Mr. Brown: We have not tried that. We have, however, used india-rubber sponge, cut into small squares, with caustic paste, but we found it to be such a dirty process that we gave it up. Caustic soda, in the form of powder, is far cleaner in use, and is in our judgment the best.

Mr. Dickinson: One other question I would like to ask—How much longer will the oxygen sustain animal life than the same volume of air? Chemists estimate it, without having the carbonic acid absorbed, at three times the duration. Do you accept that as correct?

Mr. Brown: This quantity of oxygen would, no doubt, last three times as long as the same quantity of common air. I cannot, however, speak from actual experiment.

Mr. Dickinson: The No. 3 Denayrouze instrument is dependent entirely upon compressed air; and the air, after respiration, is passed into the atmosphere and got rid of.

Mr. Brown: Do you know the size of the cylinder that takes that in? You have, I suppose, seen Denayrouze's Apparatus?

Mr. Dickinson: Yes.

Mr. Brown: It is not an apparatus where tubes are used.

Mr. DICKINSON: There are different kinds. One is where a tube is used; another is where compressed air is used. I should like to know, also, how many hours any person has actually used this Fleuss apparatus,—whether anyone has breathed through it for four consecutive hours?

Mr. BROWN: Not for four hours continuously. But at Seaham the apparatus was used by one individual for two hours.

Mr. DICKINSON: What is the effect on the system of its continuous use?

Mr. BROWN: Merely to make you warm. I had it on myself for thirty-seven minutes, as I have already stated, but I only felt that I was perspiring. That, however, was with the fire which produced the smoke that I was in.

Mr. DICKINSON: It is understood that if you breathe oxygen for any lengthened period, it has an effect of changing the character of the blood into that of arterial blood.

Mr. BROWN: I think it has only a stimulating effect when breathed for a limited period. If a man used this apparatus continuously for, say, twenty-four hours, no doubt it would affect him very seriously; but for two hours' work it only stimulates him. It is exhilarating in its effects. I felt very much better at the end of the thirty-seven minutes that I had it on than I did after the first quarter of an hour. I was ready to go on for a full hour, but the people got tired waiting outside, and they thought the thirty-seven minutes sufficient.

Mr. DICKINSON: May I ask if the idea is that the apparatus should be used as a means of restoring ventilation after it has been disarranged, or is it to find access to shut-up miners and to bring them out?

Mr. BROWN: The uses to which it should be put will be left to the mining people themselves, when they know its capabilities. They will know best what uses to apply it to.

It has already been tested, as you know, in the case of Seaham, in re-opening a mine after an explosion. We have tested it in smoke, in sulphurous fumes, deadly vapours, and gases of all kinds.

Mr. DICKINSON: What we have seen here must have convinced us that if the fittings are all tight, and the valves right, you could enter any atmosphere.

Mr. BROWN: No matter how deadly.

Mr. DICKINSON: But in the event of a person with that apparatus upon his back, after half an hour's passage through irrespirable gas, coming upon half a dozen men, what then is to be done?

Mr. BROWN: Two men together could bring a miner out; but one, acting alone, could hardly do so.

Mr. DICKINSON: Yes; but I have known a rescuer even laid hold of, and who had to tear himself away from sufferers, who wished him to remain and die with them; and I should like to know, in the event of access being available only through irrespirable gas with no retreat, except for the person using the apparatus, what are the others to do?

Mr. BROWN: But there is no reason why an explorer, knowing that men were in a certain place from which there was no retreat except through a poisonous atmosphere, should not take with him an extra set of apparatus. One man should not go into any deadly gas by himself. If it is to rescue life, knowing that there is a certain space to be traversed through a deadly atmosphere, two men should certainly take a spare Breathing Apparatus with them for those whom they found to put on.

Mr. DICKINSON: If the rescuers could carry some portable apparatus with them of a lighter construction than this, the persons who are shut up might safely be brought out. Dr. Hutchinson lays stress upon the fact that the quality of the air they have to breath is much more important than the

quantity. Even a bladder-full, he said, if carefully used, might bring a person through a long mixture of almost irrespirable gas. There is also now the portable apparatus by Mr. D. Rhys Jones, whose agent, Mr. James Davies, of Carmarthen, has sent me the drawing, which I hold in my hand. (See sketch and description.)

Mr. BROWN: It is only a matter of detail to make this lighter and smaller. There is no reason why we should not lighten it, and make it a two hours machine, if that would be more serviceable; but for actual work it is better to have a margin if you go into any danger. So we keep to the four hours till it is actually proved to us that a smaller one would be the best.

Mr. DICKINSON: I recollect the opening out of the Ince Hall Colliery, at Wigan, after a serious explosion about thirty years ago. The present Mr. James Darlington, one of the rescuers, came upon a man who had got his empty water bottle full of fresh air, and he attributed his safety to using the air in that bottle, coming through the almost irrespirable after-damp.

Dr. LE NEVE FOSTER enquired how the oxygen was produced—whether at the mine, as occasion required, or whether it was supplied by the patentees of the apparatus?

Mr. BROWN said it might be either way. The readiest way was to keep a supply of bottles always full. Two dozen bottles might be kept at each station—supposing stations were formed—and when one dozen were empty, they might be sent to London to be re-filled.

Dr. LE NEVE FOSTER: And these bottles are so constructed that there would be no leakage?

Mr. BROWN: None at all. The oxygen may be kept for any length of time.

Dr. LE NEVE FOSTER: The proportions of oxygen and nitrogen in air will be, by weight, 23 of oxygen to 77 of

nitrogen; therefore, if you had to carry air down a coal mine, it seems to me you would have to carry more than four times as much air as you would of oxygen.

Mr. BROWN: Yes.

Dr. LE NEVE FOSTER: And therefore the advantage, with respect to your apparatus, is that you have to carry a small amount; the disadvantage is that, in place of nitrogen, you have to carry this filter with caustic soda.

Mr. BROWN: Caustic soda and tow.

Dr. LE NEVE FOSTER: Mr. Dickinson asked a question about the length of time that it is possible for a person to use the respirator. You said that two hours was the longest time that it had been used. The soda you are using—which is caustic soda—will be gradually converted into carbonate, and I should like to ask whether there will not be formed an outer coating of carbonate of soda, and whether, supposing this to get pretty thick, absorption will not be prevented?

Mr. BROWN: No; we have tested that. When the apparatus is in use, the caustic soda becomes so heated that it breaks that cake away, and you find it lying on the tow. I have taken it off a man who had been under water for two hours, and that is how we find it. If, however, the cake were allowed to get hard when the apparatus is put aside for some time, you would have to rub it off. When the apparatus is in constant use, the carbonate of soda breaks away with the heat.

Dr. LE NEVE FOSTER: I am glad to have that explanation.

Mr. TONGE, referring to Mr. Dickinson's paper, in which it was stated that the Secretary of State recommended that stations should be organised in the mining districts for Fleuss's Apparatus, asked if the Government would be prepared to contribute anything towards the cost of such stations?

Mr. DICKINSON: In accordance with my instructions, received from the Secretary of State, I have brought the matter under the notice of the principal persons interested in my district. Notably, I brought it under the notice of Mr. Peace, the Secretary of the Coal Association, who promised that it should be laid before that Association at its next meeting. It had been mentioned at one of their previous meetings; and they had also, he believed, had it before them that afternoon, but with what result he was unable to say.

Mr. PILKINGTON said that at the meeting referred to by Mr. Dickinson, that afternoon, there was not a large attendance of the members. The matter was referred to each separate district, because if the apparatus was generally adopted it would have to be worked in districts. It would never do for a large district like that of Lancashire, Cheshire, and North Wales to be dependent upon a single station. Places like Manchester, Wigan, St. Helens, and Rainford would need to have separate stations. He would like to ask a question with regard to the apparatus: the outlet valve was open, and always feeding, as he understands?

Mr. BROWN: Yes.

Mr. PILKINGTON: How is it you cannot make the other valve—that in the knapsack—always feed, to admit the oxygen constantly and regularly?

Mr. BROWN: You can, if you like it better. I like to give myself a draught now and then. The two valves are exactly alike. When you have gained the necessary confidence, you will be able to work it readily. It is well, at first, to take a little draught and absorb that before taking more.

Mr. HALL said he wished that Mr. Dickinson had told them which of the different inventions he described was, in

his judgment, the best. There would be found, he believed, plenty of opportunities for the use of such an apparatus in mines. It would be much more likely to save property than to save life; and on that account he thought it would commend itself more to colliery owners and colliery managers.

Mr. PILKINGTON said he could not permit the latter statement to go unchallenged. Mr. Hall had said that colliery proprietors valued their property more than the lives of the men. This he utterly denied.

Mr. HALL: I would utterly deny that too. I say it is likely to be more useful in saving property than in saving life; that is my opinion, and I think it is an argument that would tell with colliery owners.

Mr. DICKINSON: I think the apparatus would be exceedingly useful in saving property, in the way Mr. Hall, has referred to, and it might also save life; because in the opening out of stoppings with this apparatus, you have the opportunity of seeing whether a fire is out or not, before air is turned on that might make gas into an explosive mixture. It, or some other apparatus of the kind, enabling you to enter irrespirable gas, would also admit of stoppings being made up quicker after an explosion. Promptitude of action seems to be the great thing that is desirable when a fire takes place in a colliery. These fires are not so numerous now as they used to be in this district. Still they do occur; perhaps fire-damp gets lighted and sets the mine on fire; but more means are taken now to have appliances ready than were used in former times. For instance, you now occasionally come upon an extincteur, both at the top and at the bottom of a pit, ready for use in the workings; and there are colliery owners in this district who have hose in certain lengths ready for use, which they can take down the pit. In one instance, I believe, they took down the pit and ran in 1000 yards of hose along the levels, having screw-holes and

valves ready for attachments with the water-pipes, and after the lapse of only half an hour, they were playing upon the fire; and, in this instance, the fire was extinguished with no loss of life and hardly any damage to property.

JONES' PATENT APPARATUS FOR SAVING LIFE FROM COLLIERY EXPLOSIONS, &c.

A—Iron reservoir carried by straps B B.

N—Tube conveying air to the expansible bag M.

C—Tube conveying air from the bag to the mouth-piece F.

E e—Key for regulating the supply of air to the bag.

This invention is meant to reduce the fatality of colliery explosions by providing miners who have escaped violent

injuries, and more especially to individual members of rescue parties with an immediate supply of fresh air. It is intended that a number be left down in the mine at well-known and most accessible points, or placed ready at the mouth of the pit. It weighs only 14lbs., so that each one of a rescue party can carry with him two others besides the one for his own use. Each apparatus supplies sufficient air for thirty to forty minutes. Thus each man takes with him sufficient air for himself for about one and a half hours, should he be delayed. The price is five guineas.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XVII. SESSION 1883-84.

ANNUAL MEETING.

The ANNUAL MEETING of the Members of the Society was held on Tuesday, the 2nd day of October, 1883, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., J.P., President,
in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected ordinary members of the Society:—

ROBERT HOLT EDMONDSON, 28, York Street, Manchester.
JOHN RICHARDSON HEWITT, Mining Engineer, Derby.
JONATHAN ISHERWOOD, Tyldesley.

The following are the recent additions to the Library:—

Bristol Natural History Society: Proceedings, Part 1, Vol. IV.; List of Members, &c., 1883; *From the Society.* Cambridge University Library: Annual Report, 1883. Chester Society of Natural Science: Annual Report, 1882-83. Cornwall: Journal of the Royal Institution, Part 4, Vol. VII., July, 1883; *From the Institution.* Miners' Association of Cornwall and Devon: Reports and Proceedings for 1882; *From the Association.* Dublin: Royal

Geological Society—Journal, Part 2, Vol. VI., N.S., 1881-2; *From the Society*. Essex Field Club: Transactions, Part 7, Vol. III., 1883; *From the Club*. Forster's Strata: a Treatise on a section of the strata from Newcastle-upon-Tyne to Cross Fell; by Westgarth Forster—3rd Edition, 1883; *Purchased*. Glasgow: Geological Society of Glasgow—Transactions, Part 1, Vol. VII., 1881, 1881-82; *From the Society*. Geikie, James: Prehistoric Europe, 1881; *Purchased*. Leicester Literary and Philosophical Society: Transactions for 1882-83; *From the Society*. London: Geological Society—Quarterly Journal, No. 155, Vol. XXXIX.; *From the Society*. Institution of Mechanical Engineers—Proceedings, No. 2; April, 1883; *From the Institution*. Society for Psychical Research—Proceedings, Parts 1—3, Vol. I.; *From the Society*. Royal Society—Proceedings, No. 225-6, Vol. XXXV.; *From the Society*. Geological Magazine—No. 228—231, Vol. X.; *Purchased*. Manchester Field Naturalists' Society: Report and Proceedings for 1882; *From the Society*. Midland Institute of Engineers: Transactions, Parts 45-48, Vol. VIII.; *From the Institute*. Mining Institute of Scotland: Transactions, Parts 2-4, Vol. V.; *From the Institute*. Nicholson, W. Alleyne; Manual of Palæontology, 1879; 2 Vols. *Purchased*. Ormerod, G. W.: Classified Index to Library of the Geological Society of London; Second Supplement, from 1876—82; by G. W. Ormerod; *From the Author*. Owens College Calendar, Session 1883-84; *From the Council*. Ricketts, Charles, M.D., F.G.S.: Pebbles in Boulder Clay of Cheshire and Lancashire; Oscillation of the Earth's Crust; two Pamphlets; *From the Author*. South Wales Institute of Engineers: Proceedings, No. 4, Vol. XIII.; *From the Institute*. Warwickshire Naturalists' and Archæologists' Field Club: Proceedings for 1882; *From the Club*. America: Alexander Agassiz—Bulletin of the Museum of Comparative Zoölogy, Cambridge, Mass., Nos. 5-6, Vol. X.; Nos. 1-2, Vol. XI.; whole series, Vol. VII.; Geological series, Nos. 9-10, Vol. 1; *From Prof. A. Agassiz*. Indiana: Department of Geology and Natural History—Twelfth Annual Report, by John Collett, State Geologist; *From the Department*. Eleventh and Twelfth Annual Reports, by John Collett, State Geologist; *From W. H. Fogg*. Smithsonian Reports for 1863, 1866, and 1869; *From the Institution*. Tertiary History of the Grand Cañon District (with ATLAS,) by Captain C. E. Dutton; *From the Director of the U. S. Geological Survey, Washington*. List of Palæozoic Fossil Insects of the United States and Canada, by R. D. Lacoe; *From the Wyoming Historical and Geological Society*. Canadian Institute—Proceedings, Fas. 4, Vol. I.; *From the Institute*. Cambridge—Science, No. 15, Vol. 1. Australia: Report of the Chief Inspector of Mines, Victoria, for 1882; Report for 1882 of the Trustees of the Public Libraries, Museums, and National Gallery, Victoria; Reports of the Mining Surveyors and Registrars, Victoria, (quarter ending March 31st, 31st, 1883); Mineral Statistics of Victoria, for 1882; Report of the

Inspector of Explosives, for 1882, Victoria; *From the Secretary of State, Victoria.* Sydney Public Free Library—Report for 1882. Zeitschrift der Deutschen Geologischen Gesellschaft: Band XXXV., Hefte 1-2, 1883; *From the Society.* R. Accademia dei Lincei: Transunti, Vol. VII., Fas. 11°—14°, 3 Serie; *From the Academy.* L'Académie Impériale des Sciences de St. Pétersbourg: VII° Série, Tome XXXI., Nos. 2, 3, and 4; *From the Academy.* Buenos Ayres: Estadística de Comercio y de la Navegacion, Estadística de la República Argentina, for 1882; *From the Government.*

REPORT OF THE COUNCIL.

Session 1882-83.

At the conclusion of the Session, 1882-83, your Council is pleased to have a favourable Report to make as to the general position of the Society.

There were six meetings held in Manchester, and three in Wigan. All with the exception of one in Wigan—which had to be adjourned—were well attended, and considerable interest was shown in the various subjects introduced.

As intimated in last year's Report, stock of the nominal value of £100 has been added to the invested capital of the Society, at a cost of £109 2s. 6d., and it is intended shortly to add a further like amount.

For the first time during the past eight years there is a falling off in the number of Members enrolled, which now number 16 Honorary, 8 Life, 192 Ordinary—total, 216—against 18 Honorary, 8 Life, 199 Ordinary—total, 225—at the same time last year.

The falling off is due to several causes—7 by death, 7 by resignation, and 1 by the removal of names in consequence of non-payment of subscriptions. One Honorary Member's name has been removed in consequence of communications being returned, the Post Office authorities being unable to deliver them owing to change of address.

There appears to have been considerable apathy on the part of a large number of Members with reference to the payment of their subscriptions, and your Council would suggest that if Members would direct payment by their bankers it would be a considerable saving of trouble to themselves, as well as to the officials of the Society.

It is pleasing to find that the Honorary Treasurer—as shown on his statement, which is appended—has a surplus balance of £126 2s 9d. in the Bank, after having invested the sum of £109 2s. 6d. already referred to, and notwithstanding the large amount of subscriptions still out-standing.

The Library, as heretofore, has been greatly increased during the Session by presentation, exchange, and purchase, —a list of the additions will be found appended.

As in the Session now concluded, it is proposed in the ensuing one to hold three Ordinary Meetings at Wigan.

Your Council take this opportunity of officially expressing to the Mayors of Wigan the best thanks of the Society for having so courteously placed the Council Chamber of the Municipal Authorities at the Society's disposal for holding their meetings; also to Mr. Maskell W. Peace, F.G.S., for kindly placing the new building which has been erected for the Mining School at the disposal of the Society for the same purpose.

There have been two Excursions during the summer. One organised and lead in July to Castleton, Derbyshire, by Professor W. Boyd Dawkins, to whom the thanks of the Society are due. The second was arranged for by the Honorary Secretaries to Liverpool in September, when about 80 Members and their friends took part, together with a party from the South Staffordshire and East Worcestershire Institute of Mining Engineers, who joined in response to an invitation sent to the Secretary, Mr. Alexander Smith, C.E., of Dudley. It is with much

pleasure your Council notices the good feeling which exists between the two Societies, and several of our Members have pleasant recollections of a most enjoyable and instructive Excursion made together to the Midland Counties three years ago.

Death has been very busy during the Session, and it is the melancholy duty of your Council to place on record the loss of:—

Mr. Charles Morton, who has been an Honorary Member since the formation of the Society. He was for several years one of H.M.'s Inspectors of Mines, and retired in 1867 owing to ill-health.

Mr. J. G. Lynde, F.G.S., elected in 1861. City Engineer for many years, but recently in private practice.

Mr. Peter Pickup, F.G.S., elected 1861. Managing partner of Messrs. Brooks and Pickup, at the Towneley Collieries, near Burnley.

Mr. Peter Spence, F.C.S., elected 1862, whose intimate connection with the chemical industries and discoveries, as well as many of the most important social movements of this important city and surrounding towns, &c., is universally known.

Mr. John Waddington, elected 1877, who, through his practical talent and energy, raised himself to the important position of consulting engineer for the extensive collieries belonging to the executors of Colonel Hargreaves, and in which he began working, as usual in those days, at a very young age, and one now prohibited by the laws of the country. He has also held the appointment of Examiner, to which he has annually been elected by the Board for the granting of Colliery Managers' Certificates, since the Coal Mines Regulation of 1872 came into force.

Mr. C. W. Dixon, elected 1879, and Mr. Lewis Jackson, elected in 1877.

Dr. **MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET, 1882-3.** *Cr.*

Abstract of Receipts.	£	s.	d.	Abstract of Payments.	£	s.	d.
1882-3.—To Balance brought down	159	2	7	1882-3.—By Library	3	12	6
,, Birkenhead Dividends.....	23	7	0	,, Transactions	46	19	0
,, Lancashire and Yorkshire Dividends	3	17	9	,, Reporters.....	11	8	0
,, Sale of Transactions	1	7	0	,, Circulars, Stationery, &c. ..	8	4	9
,, Subscriptions	176	10	0	,, Postages, &c.	23	4	9
,, Arrears.....	7	0	0	,, Meetings, Extra Expenses.	3	0	0
,, Bank Interest	2	2	5	,, Collectors' Commission	9	3	6
,, Bonus Insurance Office	1	6	0	,, Rent, &c.....	30	0	0
				,, Attendance, Library, &c....	2	10	0
				,, Insurance two years.	1	5	0
				,, Purchase of Stock. (L. & Y. Ry. Consol. 4 °/₀ Pref.)..	109	2	6
				,, Balance in the Bank	126	2	9
	£374	12	9		£374	12	9
1883. October.—To Balance brought down	£126	2	9				

The Investments consist of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway, and £100 Lancashire and Yorkshire Consolidated Four per cent. Preference Stock, in the names of Henry Mere Ormerod and Andrew Knowles.

Audited and found correct, 29th September, 1883.

ALFRED PILKINGTON,
JOHN GREENWOOD, Jun., } Auditors.

HENRY M. ORMEROD, Treasurer.

22nd September, 1883.

The Society further possesses a valuable Library, and about £36 arrears of Subscriptions.

	£	s.	d.
Subscriptions received for 1882-83.....	176	10	0
Arrears received	7	0	0
Arrears remaining	36	18	0
	£220	8	0

ARREARS REMAINING, OCTOBER, 1883.

	£	s.	d.
24 for 1882-83	24	0	0
8 ,, 1881-82	8	0	0
3 (less 2s.) for 1880-81	2	18	0
1 for 1879-80	1	0	0
1 ,, 1878-79	1	0	0
	£36	18	0

THE FOLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS WHICH HAVE BEEN BROUGHT BEFORE THE ORDINARY MEETINGS DURING THE SESSION:—

1882.

November. Thompson, Joseph. "On the Measurement of Air Currents."

December. "On Centrifugal Fans." Discussion.
The Owens College.
The Permian Rocks of Manchester.
The Measurement of Air Currents in Mines.
De Rance, C.E., Assoc.Inst.C.E., F.G.S. "On the Occurrence of Manganese and Hæmatite at Nant Uchaf, near Abergele, Denbighshire, in Old Red Sandstone or Carboniferous Basement Beds."

1883.

January. A New Anemometer, with Diagram.
The Permian Rocks, South of Manchester.

February. Dickinson, Joseph, F.G.S. "Notes on Safety Lamps."

Green, James S. "The Mueseler Safety Lamp and Testing Apparatus in use at Celynen Colliery, Monmouthshire."

Morton, G. H., F.G.S. "On the Strata between the Carboniferous Limestone and the Coal Measures in Denbighshire and Flintshire."

March. Kinahan, G. H., M.R.I.A. "Notes on Fault-Rock," with Diagrams.

Burnett, R. T., F.G.S. "Section of Strata passed through in Artesian Well-boring at Ardwick."

April. Dickinson, Joseph, F.G.S. "On Respirators and Lamps for penetrating Noxious Gases."

Discussion.—"On the Mueseler Safety Lamp and Testing Apparatus at Celynen Colliery."

Watts, William, F.G.S. "Interesting Sections of Strata at Readycon Dean, Saddleworth.

June. "The Fleuss' Breathing Apparatus and Lamp." Description and Discussion, illustrated.

The following noblemen and gentlemen were unanimously elected as Officers and Members of the Council for the ensuing year:—

President:

EDWARD PILKINGTON, J.P.

Vice-Presidents:

WILLIAM BRYHAM, J.P.
CLEGG LIVESEY.
MARK STIRRUP, F.G.S.
E. LEADER WILLIAMS, M.Inst.C.E.

Ex-Officio Vice-Presidents:

JAMES HEYWOOD, F.R.S.
G. W. ORMEROD, F.G.S.
JOSEPH DICKINSON, F.G.S.
ANDREW KNOWLES.
G. C. GREENWELL. F.G.S.
JOHN AITKEN, J. P.
JOHN KNOWLES, M.Inst.C.E.
THOMAS KNOWLES, M.P.
W. BOYD DAWKINS, F.R.S.
R. CLIFFORD SMITH, F.G.S.

JOHN EDWARD FORBES, F.G.S.
RIGHT. HON. THE EARL OF CRAWFORD & BALCARRES.
SIR U. J. K-SHUTTLEWORTH, BART.
GEORGE GILROY, M.INST.C.E.

Hon. Treasurer:

HENRY MERE ORMEROD, F.G.S.

Hon. Secretaries:

JOSEPH S. MARTIN, F.G.S. | JOHN E. FORBES, F.G.S.

Other Members of the Council:

W. S. BARRETT.
CHRISTOPHER F. CLARK.
G. C. GREENWELL, Junr., F.G.S.
JOHN GREENWOOD, Junr.
HENRY HALL.
CHARLES HARDWICK.
JOHN L. HEDLEY.
G. H. HOLLINGWORTH, F.G.S.
GEORGE PEACE.
J. F. SEDDON.
GEORGE WILD.
H. A. WOODWARD.

Hon. Auditors:

ALFRED PILKINGTON. | JAMES ATHERTON.

NEW ORDINARY MEMBERS.

Caldwell, George.
Cunliffe, James.
Greensmith, Thomas.
Mather, William Penn.
Shortrede, Thomas.

MEMBERS DECEASED.

Morton, Charles *(Hon. Member)*.
Dixon, Charles W.
Jackson, Lewis.
Lynde, J. G., F.G.S.
Pickup, Peter, F.G.S.
Spence, Peter, F.C.S.
Waddington, John.

MEMBERS RESIGNED, &c.

Hawkins, B. W., F.G.S. *(Hon. Member)*.
Barnes, Richard J.
Hall, Robert.
Hodgekiss, John.
Jeffcock, Charles E.
Phillips, Herbert.
Stephens, James H.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey-, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-2-3, 77-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.Inst.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1878-9	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.

LIST OF MEMBERS.

OCTOBER, 1883.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachusetts, U.S.A.
1863	Aitken, John, J.P., Clifton Villas, Urmston. *Past-President.*
1879	Arrandale, John Thomas, Bradford Colliery, Manchester.
1877	Arthur, David, Baxendale Collieries, near Accrington.
1865	Ashworth, Edward, Stag Hills, Waterfoot, near Manchester.
1878	Ashworth, James, Mapperley Colliery, West Hallam, Derby.
1878	Ashworth, Thomas, 32, St. Ann's Street, Manchester.
1877	Atherton, James, 16, Acresfield, Bolton. *Hon. Auditor.*
1878	Atkinson, Samuel C., Stand Lane Colliery, Radcliffe.
1878	Atkinson, W. N., H.M. Inspector of Mines, Shincliffe Hall, Durham.
1881	Aubrey, Richard Charles, Standish, near Wigan.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool. *Member of Council.*
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1879	Baxter, Henry, Tyldesley Colliery, Tyldesley.
1858	Bazley, Sir Thomas, Bart., Riversleigh, Lytham.
1877	Beswick, James, Shakerley Collieries, Tyldesley.
1881	Black, W. G., F.R.C.S.Ed., F.G.S.Ed., 2, George's Square, Edinburgh.
1867	Bolton, H. H., Newchurch, near Manchester.

Year of Election.	
1880	Bolton, H. H., jun., Newchurch, near Manchester.
1880	Boot, John Thomas, The Orchards, Hucknall Huthwaite, near Mansfield.
1878	Bradford, The Right Hon. the Earl of, Weston Park, near Shifnal.
1882	Bradley, F. Lewis, Bel-Air, Alderley Edge.
1878	Brocklehurst, Thomas, Dean, Bolton.
1877	*Broeck, Ernest Vanden*, 124, Rue Terre Neuve, Brussells.
1880	Bromley, Thomas, 17, Hind's Fold, Elton, Bury.
1877	*Brongniart, Charles*, Museum d'Histoire Naturelle, 57, Rue Cuvier, Paris.
1861	Brooks, Thomas, Crawshay Hall, Rawtenstall.
1880	Brown, Wm. Speakman, 14, Trevelyn Bank, Abbey Grove, Eccles.
1859	Bryham, William, J.P., Ince Hall, Wigan. *Vice-President.*
1881	Bryham, Wm., jun., Douglas Bank Colliery, Wigan.
1862	*Buccleuch, His Grace the Duke of, Whitehall Gardens, London, S.W.
1882	Burnett, R. T., F.G.S., Cresswell Grove, Albert Park, Didsbury.
1879	Burns, Thomas, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., Yew Tree House, Atherton, near Manchester.
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1879	Carter, James, 1, Granville Terrace, Blackburn.
1881	Clark, Christopher F., Park Lane Collieries, Wigan. *Member of Council.*
1882	Clark, George, Lea Farm, Twycross, Atherstone, Leicestershire.
1878	Clayton, Abel, 11, Chapel Walks, Manchester.
1882	Cockson, Charles, King Street, Wigan.
1878	Cooke, Charles, Marehay Main Colliery, Ripley, near Derby.

Year of Election.	
1859	*Coulthart, John Ross, F.R.S.,Lit., F.S.A.,Scot., Croft House, Ashton-under-Lyne.
1878	Cowburn, Henry, West Leigh, near Manchester.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1880	Crompton, William, Ince, near Wigan.
1862	Cross, John, 77, King Street, Manchester.
1860	Crowther, Samuel, Bradford Estate Office, Bolton.
1882	Cunliffe, James, 266, Bolton Road, Chorley.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Past-President.*
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley.
1882	Devonport, John, Chamber Collieries, Oldham.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Past-President.*
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1880	Duncan, William, M.D., Prospect House, Tyldesley.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Old Hall, near Manchester.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskillen, The Right Hon. the Earl of*, F.R.S., Florence Court, Fermanagh.
1865	Evans, Walter, Longsight, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1880	Fairley, Joseph Smith, 64, Victoria Street, Liverpool.

Year of Election.	
1863	Farrar, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1857	Forbes, John Edward, F.G.S., 42, Clarence Road, Birkdale, Southport. *Past-President, and Hon. Secretary.*
1873	Garforth, W. E., Colliery Offices, Normanton.
1874	*Geikie, Archibald*, LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy, George, M.Inst.C.E., Woodlands, Parbold, Wigan. *Past-President.*
1881	Gilroy, Samuel B., Ambergate, near Derby.
1882	Glover, B. B., Haydock, near St. Helens.
1881	Goodhall, John, Handsworth, Woodhouse, near Sheffield.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1882	Gresley, W. Stuckley, F.G.S., Overseal, Ashby-de-la-Zouch.
1863	Greenwell, G. C., F.G.S., Duffield, Derby. *Past President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport. *Member of Council.*
1879	Greenwood, John, jun., Ashton Moss Colliery, Audenshaw, Manchester. *Member of Council.*
1879	Gregson, Edward, 11, Chapel Street, Preston.
1883	Greensmith, Thomas, Moston Colliery, Failsworth, Manchester.
1880	Grimke, Theodore Drayton, Whitledgehurst, Ashton-in-Makerfield.
1880	Grimshaw, H. Stott, Stand Lane Colliery, Radcliffe.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1877	Grundy, Joseph, Colliery Surveyor, Radcliffe.
1879	*Gosbal, Theophile*, Professor d'Exploitation des Mines, Mons, Belgium.

Year of Election.	
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot. *Member of Council.*
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester. *Member of Council.*
1880	Hargreaves, John, Collyhurst Paper Mills, Manchester.
1874	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.*, State Geologist, Washington, U.S.A.
1882	Heathcote, William, Farnworth, near Bolton.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester. *Member of Council.*
1875	Hetherington, Joseph, 22, Booth Street, Manchester.
1874	Hewlett, W. H., Wigan Coal and Iron Company, Wigan.
1880	Heys, James, Westleigh, Leigh, near Manchester.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Past-President.*
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, J., Wigan Coal and Iron Company, Wigan.
1878	Holden, Charles H., Mawdsley Street, Bolton.
1877	Holding, William, Crossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., Hollinwood, Manchester. *Member of Council.*
1878	Howell, John, Astley, near Manchester.
1874	*Hull, Professor Edward*, M.A., F.R.S., 5, Raglan Road, Dublin.
1880	Hulton, W. W. B., J.P., Hulton Park, near Bolton.
1878	Jackson, Charles G., Chamber Colliery Offices, Hollinwood, Manchester.
1875	Jackson, J., 5, Wood Street, Bolton.
1880	Jackson, William, 75, Broadway Street, Oldham.

Year of Election.	
1879	Johnson, Isaiah,
1882	Johnson William, Abram Colliery, Wigan.
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1880	Kennedy, Matthew, 79, Broadway Street, Oldham.
1882	Kenney, George, 11, King Street, Wigan.
1879	*Kinahan, G. H.*, M.R.I.A., Lurgybrack, Letterkenny, Ireland.
1856	Knowles, Andrew, Swinton Hall, Swinton, near Manchester. *Past-President.*
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury. *Past-President.*
1882	Knowles, Israel, Ince Coal and Iron Company, Wigan.
1877	Knowles, Lees, M.A., L.L.M., Westwood, Pendlebury.
1858	Knowles, Thomas, M.P., Darnhall Hall, Winsford, Cheshire. *Past-President.*
1858	Lancaster, John, F.G.S., Bilton Grange, Rugby.
1862	Livesey, Clegg, Poise House, Torkington, near Stockport. *Vice-President.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1878	Longbotham, Jonathan, Norley Colliery, Wigan.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., M.Inst.C.E., 4, Albion Place, Leeds.
1881	MacAlpine, G. W., Whinney Hill Colliery, Accrington.
1878	Maiden, Sampson, Bridgewater Villas, Stockport.
1873	Martin, Joseph S., F.G.S., H.M. Inspector of Mines, Park Villas, Prestwich. *Hon. Secretary.*
1883	Mather, William Penn, Iron Works, Salford.
1879	Melling, William.
1881	Merfyn, A., care of Messrs. Higson, 18, Booth Street, Manchester.

Year of Election.	
1876	Moore, Alfred, C.E., 5, Clarence Street, Manchester.
1874	*Morton, G. H.*, F.G.S., 122, London Road, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1878	Nelson, William, Abram Colliery, Bickershaw, near Wigan.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1838	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth. *Past-President.*
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester. *Hon. Treasurer.*
1874	*Owen, Professor Richard*, D.C.L., F.R.S., South Kensington Natural History Museum, London, S.W.
1862	Park, James, Fern Hill, Bury.
1880	Parish, Arthur Woodbine, Clowes House, Higher Broughton, Manchester.
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grove, Eccles. *Member of Council.*
1877	Peace, Maskell, W., F.G.S., Wigan.
1881	Pearson, A., Dukinfield Cottage, near Ashton-under-Lyne.
1876	Penman, J. Hugh, 2, Clarence Buildings, Booth Street, Manchester.
1881	Pennington, A. S., Wood Street, Bolton.
1877	Pennington, Rooke, F.G.S., 14, Acresfield, Bolton.
1882	Percy, C. M., King Street, Wigan.
1878	Perrin, J. Beswick, M.R.C.S.E., F.L.S., Leigh, near Manchester.
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester, *Hon. Anditor.*
1879	Pilkington, Charles, Ashton and Edge Green Collieries, St. Helens.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *President.*

Year of Election.	
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Astley Deep Pit, Dukinfield.
1874	*Ramsay, Sir A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton.
1882	Rigby, William, Leader's Buildings, King Street, Wigan.
1877	Robins, George, Ashton, near Newton-le-Willows.
1882	Sacré, R. A., 20, Cooper Street, Manchester.
1880	*Schofield, Christopher James, Whalley Villa, Whalley Range, Manchester.
1881	School of Mines, Columbia College, New York. The President (for the time being) of the. (To be addressed to Mr. H. Grevel, 33, King Street, Covent Garden, London.)
1873	Seddon, J. F., Great Harwood, Accrington. *Member of Council.*
1866	Selby, Atherton, Mining Engineer, Leigh.
1882	Settle, Joel, Darcy Lever Collieries, Bolton.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1883	Shortrede, Thomas, Winstanley, near Wigan.
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	Smethurst, William, F.G.S., Garswood Hall Colliery, Ashton, near Wigan.
1838	Smith, G. F., M.A., F.G.S., Groveburst, Tunbridge Wells.
1881	Smith, John, Bickershaw Collieries, Westleigh.
1873	*Smith, R. Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Past-President.*
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.

Year of Election.	
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1881	Squire, J. B., A.Inst.C.E., 1, Milton Road, Herne Hill, London, S.E.
1859	Statter, Thomas, Stand Hall, Bury.
1880	Stirrup, Mark, F.G.S., Richmond Hill, Bowdon. *Vice-President.*
1882	Stopford, T. R., Park Hall Colliery, Blackrod, Lancashire.
1882	Storey, Edward, Leigh, Lancashire.
1881	Taylor, Alfred, Norley Collieries, Wigan.
1880	Teale, William E., Fern Bank, Worsley.
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1873	Tonge, James, F.G.S., Woodbine House, Westhoughton, near Bolton.
1876	Topping, Walter, Bamfurlong Collieries, near Wigan.
1858	*Trafford, Sir Humphrey de, Bart., Trafford Park, Manchester.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1879	Unsworth, Richard, Mesne Lea Colliery, Worsley.
1877	Waddington, Henry, Burnley Collieries, Burnley.
1862	Wadham, Edward, Millwood, Dalton-in-Furness.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, 11, King Street, Wigan.
1882	Wallwork, Thomas, Colliery Office, Walkden, near Bolton.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1881	Wanlass, William, New Colliery, Westhoughton, near Bolton.
1879	Warburton, William, High Lane, near Stockport.
1880	Watts, William, F.G.S., Piethorne, Rochdale.
1878	Wells, Samuel B., 130, Bradford Street, Haulgh, Bolton.
1877	West, T. E., 65, Werneth Hall Road, Oldham.

Year of Election.	
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne. *Member of Council.*
1877	Wild, Joseph, 3, Stoneclough Road, Kearsley, near Bolton.
1880	Williams, E. Leader, M.Inst.C.E., Queen's Chambers, John Dalton Street, Manchester. *Vice-President.*
1876	Winstanley, Robert, 32, St. Ann's Street, Manchester.
1876	Woodward, H. A., Clifton, near Manchester. *Member of Council.*
1877	Yates, T. M., Anderton Hall Colliery, Blackrod, Chorley.

Members are requested to communicate immediately to the Hon. Secretaries all changes of Residences.

Belfast.—Natural History and Philosophical Society. Proceedings for Session 1881-82. ***From the Society.***

Bristol Naturalists' Society.—Part 1, Vol. IV., N.S. ***From the Society.***

Broeck, E.V.—Four Pamphlets, by E. V. Broeck. ***From the Author.***

Catalogue of Works on Natural History, including many relating to Geology. Catalogue of Periodicals, Journals, and Transactions of Learned Societies, and Issues from H.M. Government and Private Presses. (Both Catalogues possess Index for the facility of reference.) ***Presented by Mr. Bernard Quaritch.***

Cambridge University.—Report of the Museums and Lecture Rooms Syndicate. For 1882. Annual Report of the University Library, 1883.

Cornwall.—Transactions of the Royal Geological Society of. Catalogue of the Library, 1882. *From the Society.*

Cornwall.—Royal Institution of.—Journal. Parts 3 and 4, Vol. VII. 1882-3. *From the Council.*

Cornwall and Devon.—Reports and Proceedings of the Miners' Association. 1882. *From the Council.*

De Rance, C.E.—Eighth Report to British Association on Underground Water Supply. *From the Author.*

Dublin.—Royal Dublin Society.—Transactions. Vol. I., Parts 15 and 16. Proceedings. Vol. III., Part V. *From the Society.*

Dublin.—Royal Geological Society.—Journal. Part II., Vol. VI. New Series. 1881-2. *From the Society.*

Edinburgh Geological Society.—Transactions for 1881-2. *From the Society.*

Edinburgh Royal Physical Society.—Proceedings Session 1881-2. *From the Society.*

Essex Field Club.—Transactions. Parts 7, Vol. III. *From the Club.*

Glasgow Geological Society.—Transactions. Part 1, Vol. VII. *From the Society.*

Glasgow Natural History Society.—Proceedings. Parts 1-2, Vol. I.; Part 1, Vol. 5. *From the Society.*

Hertfordshire Natural History and Field Club.—Transactions. Part 2, Vol. II. *From the Council.*

Hull, Prof. E., F.R.S.—Contributions to the Physical History of the British Isles, by Professor E. Hull, F.R.S. Three Geological Pamphlets. *Presented by the Author.*

Institution of Mechanical Engineers.—Proceedings. Nos. 3 and 4, 1882. *From the Council.*

Iron and Steel Institute.—Journal. No. 2, 1882. *From the Council.*

Kinahan, G. H.—Two Geological Pamphlets. *From the Author.*

Leicester Literary and Philosophical Society.—Transactions for 1882-83. *From the Council.*

Liverpool Geological Association.—Transactions. Session 1881-2. Annual Report 1882. *From the Society.*

Liverpool Geological Society.—Proceedings, 1881-2. *From the Society.*

London Geological Society.—Quarterly Journal. Nos. 152 to 155. Abstracts of Proceedings for the Session 1882-3. List of Fellows (November, 1882). *From the Society.*

London Geologists' Association.—Proceedings. Nos. 6-7, Vol. VII. No. 1, Vol. VIII. Annual Report, 1883. *From the Council.*

London.—Royal Institution.—Proceedings. Nos. 73-74, Vol. IX. Parts 1-4-5, Vol. X. *From the Institution.*

London.—Royal Society.—Proceedings. Parts 222-26, Vols. XXXIV.—XXXV. *From the Society.*

London.—Institution of Mechanical Engineers.—No. 2. April, 1883. *From the Institute.*

London.—Society for Psychical Research. Parts 1-3. *From the Society.*

Manchester Field Naturalists' Society.—Report for 1881-82. *From the Society.*

Manchester Scientific Students' Association.—Report and Proceedings for 1882. *From the Association.*

Manchester Victoria University.—Calendars Session 1882-83 and 1883-84. *From the Council.*

Midland Institute of Engineers.—Transactions. Parts 59-68, Vol. VIII. *From the Council.*

Mining Institute of Scotland.—Transactions. Parts 6-18, Vol. IV. Parts 1-4, Vol. V. 1882-83. *From the Council.*

Morton, G. H., F.G.S.—Carboniferous Limestone and Cefn-y-Fedw Sandstone, North Wales. *Presented by the Author.*

North of England Institute of Engineers.—Transactions. Part 5, Vol. XXXI. Parts 1-4, Vol. XXXII. *From the Council.*

Norwich Geological Society.—Proceedings. Vol. I., Parts 1, 2, 4, 5, 6, 7; 6 Parts. 1878-83. *From the Society.*

Ormerod, G. W., Classified Index to Library of the Geological Society of London.—Second Supplement from 1876 to 1882. *From the Author.*

Ricketts, Charles, M.D., F.G.S.—Two Pamphlets. *From the Author.*

South Wales Institute of Engineers.—Proceedings. Parts 1-4, Vol. XIII. *From the Institute.*

Warwickshire Naturalists' and Archæologists' Field Club.—Proceedings for 1882. *From the Club.*

Yorkshire Geological and Polytechnic Society.—Proceedings. Part 1, Vol. VIII. 1882. *From the Society.*

ANNUAL REPORTS, FROM THE COMMITTEES.

Birmingham Free Library.—Report. 1881-82.

Chester Society of Natural Science. 1882-83.

Devon and Exeter Free Library. 1882-83.

Dundee Free Library. 1881-82.

Liverpool Free Library. 1882-83.

Salford Museum, Libraries, and Parks. 1881-82.

Wigan Free Library. 1882-83.

U.S. AMERICA AND CANADA.

Agassiz, Alexander.—Museum of Comparative Zoölogy, Cambridge, U.S.A. Annual Report of the Curator. 1881-82. Bulletin. Nos. 2-6, Vol. X. Nos. 1-2, Vol. XI. Whole Series, Vol. VII. Geological Series, Nos. 9-10, Vol. I.

Cambridge.—Science. Nos. 1 and 15, Vol. I.

Hayden, F. V.—U.S. Geological Survey of the Territories. Nos. 1-3, Vol. VI.

Indiana.—Department of Geology and Natural History. Eleventh Annual Report by John Collett, State Geologist. *From the Department.* Eleventh and Twelfth Annual Reports. *From W. H. Fogg.*

New York.—American Museum of Natural History. Bulletin. Parts 2-4. 13th and 14th Annual Reports, 1882-83. *From the Committee.*

Smithsonian Institution, U.S.A.—Annual Reports for 1863, 1866, and 1869. List of Foreign Correspondents (corrected to 1882). *From the Institution.*

Palæozoic Fossil Insects of the United States and Canada. By R. D. Lacoe. *From the Wyoming Historical and Geological Society.*

Tertiary History of the Grand Cañon District, *with* ATLAS. By Captain C. E. Dutton. *From the Director of the U.S. Geological Survey, Washington.*

Toronto.—The Canadian Journal.—Proceedings. Parts 3-4, Vol. I. New Series. *From the Council.*

Transactions of the American Institute of Mining Engineers.—Vol. X. 1882. *From the Council.*

Winchell, N. H., State Geologist.—Geological and Natural History Survey of Minnesota. 9th Annual Report, 1880.

AUSTRALIA.

Mineral Statistics of Victoria for 1882.

Quarterly Reports of the Mining Surveyors and Registrars, Victoria. June, 1882, to March, 1883.

Report of the Chief Inspector of Mines, Victoria, for 1882.

Report for 1882 of the Trustees of the Public Libraries, Museums, and National Gallery, Victoria.

Report of the Inspector of Explosives for 1882, Victoria. *From the Secretary of State, Victoria.*

Sydney.—Public Free Library: Report for 1882. *From the Committee.*

Annual Report of the Department of Mines, 1880-1.

Journal of the Royal Society of New South Wales, 1881.

Minerals of New South Wales.

New South Wales.—Brief Statistics and Descriptive Account of; by Thomas Richards; 1882. *From the Royal Society, N.S.W.*

NOVA SCOTIA.

Halifax.—Institute of Natural Science. Proceedings and Transactions. Part 4, Vol. V. 1881-82. *From the Institute.*

FOREIGN.

Académie Impériale des Sciences de St. Pétersbourg. Mémoires. Vol. VII. Série No. 5. Tome XXVIII. Bulletin Nos. 4-6. Tome XXX., Nos. 2-4. Tome XXXI. *From the Academy.*

Buenos Ayres.—Oficina Nacional de Estadística Comercial de la República Argentina. Statistics of Foreign Commerce. 1882. ***From the Government.***

R. Accademia dei Lincei.—Transunti. Vol. VII. Fascicolo 1°-14°. 1882-83. Memoirs. Vol. IX.-X. 1881. *From the Academy.*

Deutsche Geologische Gesellschaft.—Zeitschrift. Hefte, 2-4, Band XXXIV. Hefte, 1-2, Band XXXV. *From the Society.*

Naturforschende Gesellschaft zu Leipzig. — Sitzungsberichte. 1882. *From the Council.*

Naturwissenschaftliche Gesellschaft Isis in Dresden.—Sitzungsberichte. July to December, 1882. *From the Society.*

Rio de Janeiro.—Museu Nacional. Archivos. Vol. IV., Parts 1-4. 1879. Parts 1-4. 1880. *From the Council.*

Società Toscana di Scienze Naturali. Pisa. Memorie. Vol. V. Fas. 2°. Processi, Vol. VIII. *From the Society.*

Società Toscana di Scienze Naturali. Pisa. Processi. Vol. VIII. *From the Society.*

Société Royale Malacologique de Belgique:

Annales. Tome XIV.-XVI. Abstracts, 3 parts. 1882-83. Two Pamphlets, by M. A. Ruhat. *From the Society.*

Société Vaudoise des Sciences Naturelles. Lausanne. Bulletin. No. 88, Vol. XVIII. 1882. *From the Society.*

Société Géologique du Nord. Lille. Annales. Tome IX. 1881-82. *From the Society.*

Verein für Erdkunde zu Halle a/S. Mittheilungen für 1882. *From the Society.*

BOOKS PURCHASED 1882-83.

Forster's Strata.—A Treatise on a section of the Strata from Newcastle-upon-Tyne to Cross Fell. By Westgarth Forster. 3rd edition. 1883.

Geological Magazine. Nos. 220-31. 1882-83.

Geological Record for 1878.

Geology.—Text Book, by Dr. A. Geikie, F.R.S. 1881.

Palæontology.—Manual, by H. A. Nicholson, F.G.S. 1879.

Prehistoric Europe, by James Geikie, F.R.S. 1881.

Volcanoes, by J. W. Judd, F.R.S. 1882.

SOCIETIES WITH WHOM THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHOM A COPY IS SENT FREE.

I.—ENGLAND.

London.....British Museum.
Geological Society.
Geological Survey.
Geologists' Association.
Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute.
Royal Institution.
Royal Society.
Society for Psychical Research.

Manchester .....Field Naturalists' Society.
Free Library.
Literary and Philosophical Society.
Owens College.
Salford Royal Museum and Library.
Scientific Students' Association.

Barnsley .....Midland Institute of Mining Engineers.

Birmingham.....Free Library and Museum.

Bristol.....Naturalists' Society.
Buckhurst Hill, Essex Essex Field Club.
Camborne.....Miners' Association of Cornwall and Devon.
Cambridge.....Geological Museum, University.
University Library.
Chester.....Society of Natural Science.
Chesterfield .....Institute of Mining Engineers (in bound vols).
Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.
Dudley .....South Staffordshire and East Worcestershire Institute of Mining Engineers.
Exeter .....Albert Memorial Museum.
Leeds .....Geological and Polytechnic Society.
Philosophical and Literary Society.
Leicester .....Literary and Philosophical Society.
Liverpool .....Free Library and Museum.
Geological Association.
Geological Society.
Newcastle-on-Tyne..Institute of Mining and Mechanical Engineers.
Oxford .....Bodleian Library.
Radcliffe Library.
North Shields ....Public Free Library.
Redruth .....Mining Institute of Cornwall.
Stoke-on-Trent....North Staffordshire Institute of Mining and Mechanical Engineers.
Swansea.....South Wales Institute of Mining and Mechanical Engineers.
Warwick .....Natural History Society.
Watford, Herts....Natural History Society and Field Club.
Wigan.....Free Library.
Mining School.

II.—Scotland.

Dundee.....Free Library and Museum.
Edinburgh .....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.

Glasgow .....Geological Society.
Natural History Society.
Hamilton.....Mining Institute of Scotland.

III.—Ireland.

Dublin.....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
Belfast.....Natural History Society.

IV.—Australia.

Melbourne .....Public Library of Victoria.
Sydney.....Free Public Library.
Royal Society of New South Wales.
Newcastle.....John Mackenzie, F.G.S.

Canada and United States.

Montreal .....Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
M'Gill College (Principal, J. W. Dawson, F.G.S.)
Toronto .....Canadian Institute.
Boston, U.S. ....Free Library.
Columbus, U.S. ..Ohio, Geographical Survey of (Dr. J. S. Newberry).
Easton, U.S. ....American Institute of Mining Engineers.
Indiana, U.S.....Department of Geology and Natural History (John Collett, State Geologist).
Indianopolos, U.S. E. T. Cox, State Geologist.
Newhaven, U.S. ..Professor O. C. Marsh, F.G.S.
New York .....American Museum of Natural History, Central Park.
Washington, U.S...Department of the Interior U.S. Geological Survey.
Smithsonian Institution.
Wyoming, U.S. ..Historical and Geological Society.

VI.—Foreign Societies.

Berlin .....Deutschen geologischen Gesellschaft.
Buenos Ayres ....Officiana Nacional de Commercie.

Calcutta .....Geological Survey of India.
Christiania .....Royal University of Norway
Halle, A.S. .....Verein fur Erdkunde.
Lausanne (*Suisse*)..Sociétié Vaudoise des Sciences Naturelles.
Lille.....Sociétié Géologique du Nord.
Pisa.....Sociatà Toscana di Scienze Naturali.
Rio de Janeiro....Museu Nacional.
St. Petersburg....Acadèmie Impèrial.
Turin .....Academie Royale.

VII.—Scientific Journals, &c.

Geological Magazine, Geological Record, Mining Journal, Colliery Guardian, Iron and Coal Trades Review.

EXCURSION TO LIVERPOOL AND THE MERSEY CHANNEL TUNNEL.

On Wednesday, the 12th September, the members of the Society, accompanied by a number of gentlemen of the North Staffordshire Institute of Mining Engineers, had a most enjoyable excursion to Liverpool. The primary object was to make an inspection of the Mersey Tunnel Works, in connection with the railway which is about to be constructed between Liverpool and Birkenhead, and to see the boring machine invented by Colonel Beaumont in operation in the drainage level. They proceeded to Birkenhead, and were courteously received by Colonel Beaumont and other gentlemen connected with the undertaking, and provision was made for a descent to the level, where the machine was at work, by as many as could be accommodated within the time which was at the disposal of the party. A considerable number who were unprovided with the necessary equipment in the shape of waterproof clothing contented themselves with an inspection of the drier workings of the tunnel, through which, when the work is completed and the railway open, the traffic will pass. In this tunnel the work is carried on by the aid of the electric light. The party in their explorations had the advantage of the guidance of Mr. Davidson and others in the service of the contractor, Mr. Waddell.

Before the descent was made Colonel Beaumont gave some explanation of the work, of the machinery in use, and of the progress which had been made in cutting the tunnel up to the date of the visit. The headings of the tunnel, under the river, it was expected would be completed shortly after Christmas. Six hundred yards remained to be cut, and this would be done at the rate of 150 yards per

month, the boring machine drilling 120, and hand labour at least 30 yards. The tunnel descends at a gradient of about one in 30 from the Liverpool and Birkenhead sides respectively, to near the centre of the river, where, for a space of 550 yards, the tunnel is practically level, the gradient being only one in 900. The drainage level reaches either end of this level portion, and serves to dry the tunnel by taking the water from the points of intersection with the tunnel to the pumping stations on the Lancashire and Cheshire sides. Those visiting the drainage heading were therefore lowered to a greater depth than those who entered the tunnel. On both sides of the river access is gained to the tunnel and drainage heading by separate shafts. The drainage shafts are fitted with powerful pumps worked by two compound differential direct acting engines, made by Messrs. Hathorne, Davey & Co., of Leeds, each of about 400 indicated horse-power. There are two lifts, each 30 inches diameter and 8ft. stroke, making seven strokes per minute. The engines are supplied with steam by a set of Adamson's boilers, five in number. At the date of the visit water was being raised at the rate of about 3,500 gallons at Liverpool and Birkenhead respectively; but it was explained that, in view of the possibility of more water being found, and also to put the undertaking in a perfectly safe position as to pumping power, new pumps were in course of construction which alone would be capable of dealing with about two and a half times the volume of water now being lifted. There would thus be a pumping power sufficient to deal with from 10,000 to 15,000 gallons per minute, on either side of the river. The distance across the river from quay to quay is 1,232 yards. On the Liverpool side the drainage heading was being driven by hand, and a distance of 210 yards had been completed, while on the Birkenhead side the drainage heading was being made by Colonel Beaumont's

machine, which had reached a distance of 420 yards under the river. It was calculated that, if the rate of progress then observed was maintained, the centre of the river would be reached before the end of October. The tunnel had been completed, ready to receive the ballast and rails for a distance of 650 yards on the Liverpool side, and 800 yards on the Birkenhead side, including the construction of the stations at James' street and Hamilton square. On the Liverpool side, where the drainage heading is being driven by hand, a brick lining is used with the view of excluding the water, which is tapped on that side more freely than it is at Birkenhead, owing to the work being shaken by the explosives used. The lining is a complete barrel of brick work, in cement, underneath which is put an 18 inch cast iron main for the purpose of relieving the heading of the water while the brick work is being constructed. The three outer rings are red bricks, and inside them are three rings of best blue bricks. On the Birkenhead side, as already stated, the heading, which is 7ft. 2in. in diameter, is driven by Colonel Beaumont's machine. The machine cuts the rock, without the use of explosives, and leaves a clean side, similar to the bore of a gun, the water not interfering with the operation of boring. About ten days prior to the members' visit the machine passed from the drainage heading into the tunnel, the bottom heading of which it was then driving. The machine is driven by compressed air, supplied by engines of ordinary construction, situated in the yard of the works. The air pressure, when the machine is at work, is 35 pounds to the square inch, which is taken to the front in cast iron pipes, four inches in diameter. The supply of air necessary to work the boring machine is found amply sufficient to keep the heading in a proper state of ventilation, and this no matter at what distance the boring machine may be from the surface. The air in the heading of the Channel Tunnel, when the boring

machine was 2,000 yards from the shaft, was perfectly fresh. The machine at work on the Mersey Tunnel is similar to that which was used on the French side of the Channel Tunnel works, but certain modifications have been introduced, rendered necessary by the different character of the material to be operated on.

The machine consists, speaking generally, of a very powerful cutter head, made of cast iron, which carries the chilled disc cast iron cutters used to operate on the rock. This bore-head is attached to a steel shaft 12 inches in diameter, which, by suitable wheel work, is driven at the rate of from one to one and a half revolutions per minute by a pair of 12-inch air cylinders, the normal piston speed of which is 300 ft. per minute. The whole of the gear necessary for the above operations is carried on a cast iron bed plate which slides on longitudinal guides formed by the upper surface of the wrought iron bed resting on the bottom of the tunnel. The connection between the upper and lower beds is by means of a screw with a three-eighths pitch, which is driven by the air engine. The operation of boring consists in arming the bore-head with the cutters; the air keeping the engine at work causes the bore-head to be revolved against the rock and kept steadily pressed forward with a dead pressure due to the action of the screw at the rate of three-eighths of an inch per revolution. After about one foot has been thus cut the machine is drawn back on the bed, and the cutters are turned round to present fresh cutting edges. The operation is then recommenced, and after the cutters are worn out they are replaced by others, the old cutters being recast. The screw will admit of an advance of four feet without moving the lower bed, after which the upper bed is lifted by means of jacks, carrying the lower bed with it. The action of the screw is reversed; the lower bed is slid forward under the upper, and the jack screws are released;

after which the machine is in a position to recommence operations. The *debris* cut by the tools falls to the bottom of the heading, whence it is passed into an endless series of buckets, which take it underneath the machine, and deliver it into wagons at the back.

Many previous attempts have been made to produce machines which would enable galleries to be driven without the use of explosions, but it is claimed for Col. Beaumont's machine that it is the first which has succeeded in practice. It is based on the principle of cutting the rock at a slow speed and with enormous pressure ; whereas most inventors before have considered that the harder the rock the greater was the necessity for taking a light cut, and consequently speeding their tools at a higher rate. Col. Beaumont's method of dealing with the rock is exactly analogous to the ordinary practice in our workshops, where the harder the material requiring to be operated upon the slower must be the speed of the tool. The limit of speed with Col. Beaumont's machine depends entirely on the cutters. If more than one and a half revolutions per minute were attempted to be given in rock such as the red sandstone which is met with in the Mersey tunnel borings the heat generated from the work done would be more than could be absorbed, and consequently the temperature of the tool would increase to such an extent as to make it lose its temper rapidly. Water is, by means of jets, introduced on to the cutters; but owing to the dirt they cut it is found difficult to get the water to play upon the actual cutting edge. When better arrangements are made, Col. Beaumont is of opinion that the speed which is now got will be considerably increased.

The rock at Liverpool was, at the date of the visit, being cut at the rate of five feet per eight hour shift, or say 30 yards per week. It was anticipated with some confidence that

this speed would be eventually increased to one foot per hour—say eight feet per day. The members saw the rock cut at a greater speed than this; the reason why the average was reduced being due to certain mechanical defects in the details of the machine at work, which defects would be remedied in other machinery then under construction. The machine employed at Birkenhead had been tried upon the hard sandstone of the Woodhead tunnel, on the Manchester, Sheffield, and Lincolnshire Railway, where it was anticipated it would eventually be employed in duplicating the existing tunnel. It was found that the cutters cut the rock satisfactorily, but, owing to its being so much harder than the red sandstone, a more powerful machine will be needed. There would appear to be a large field open for the employment of the machine, if the anticipations of the inventor are realised, and it is found possible to cut the harder kinds of rock with it. The importance of doing away with the use of explosions from stone drifts in collieries need hardly be pointed out, especially in cases where the presence of fire damp is apprehended. The machine weighs about 30 tons, the weight being necessary to enable a sufficient amount of strength to be given to the various parts to stand the enormous strains which are put upon them. The power required to drive the machine is about 100 horse on the surface, one-third of which is utilised down below. The size of the machine and its weight would preclude its employment except in cases where galleries of not less than from 700 to 800 yards have to be driven—unless, indeed, the question of the use of explosives has to be considered. In a colliery where engine coal has a low value, the amount of horse power consumed by the machine is obviously of comparatively small importance.

Col. Beaumont further explained that the red sandstone rock is almost impervious to water. The water that enters

the drainage heading percolates through joints in the rock. The strata—which are in the pebble beds of the Triassic formation—lie at an angle of about one in six, the dip being from Birkenhead towards Liverpool. It might be expected that the joints, where any exist, would be filled with clay. This to a certain extent, no doubt, is so. In some places the joints are closed, and the water has no access; but in other places, where the closure is only partial, water is freely admitted. The small quantity of water entering the tunnel from under the Mersey is salt; and it was curious to note that the wettest portions of the tunnel were those which were under the land.

The members were further informed that operations had been in progress at the tunnel for the last eighteen months. The upper tunnel was 90 feet below the surface; it would be 26 feet wide by 20 feet above rail level when completed and opened for traffic. Between the top of the tunnel and the bottom of the river there will be 35 feet of solid rock, and above that 60 feet of water at low tide and 80 feet at high tide. The pump, on either side of the river, is about 80 feet below the bottom of the tunnel.

Having completed their inspection of the tunnel works the party made their way, in conveyances, to the Alexandra Dock, where the splendid Guion Line steamer Alaska was lying taking in cargo preparatory to her next voyage across the Atlantic. Through the courtesy of the owners of the vessel the party were shown over her and supplied with refreshments. After this the shipbuilding works at Birkenhead belonging to Messrs. Laird Brothers were visited, and the party had the privilege of inspecting the engineering and other workshops, and also of seeing several fine vessels in course of construction.

In the evening the members assembled at the Seacombe Hotel, and sat down to dinner—Mr. John Aitken, President of the Society, in the chair.

After the usual loyal toasts had been duly honoured,

The CHAIRMAN gave the health of Colonel Beaumont and those gentlemen who allowed the members to visit their works. Colonel Beaumont's machine, as they knew, had performed important work not only in the Mersey Tunnel, but in the Channel Tunnel also; and he believed the inventor had full confidence that if it was set to do even harder work than that on which it was now engaged it would be equal to the task. The present age might be called the age of tunnel-making and canal-cutting. There were now five or six schemes before the world for the construction of ship canals. There were the Suez Canal, the Panama Canal, the Euphrates Canal, and—not least among the number—the Manchester Ship Canal; and he saw from the newspapers that a project was mooted for connecting the Solway Frith with the Tyne by means of a ship canal. Then, as regarded tunnels, these perhaps more directly interested them, having visited one of those great undertakings during the day. The Alps had been penetrated. At present there were two railways through that great range of mountains, and the construction of another was contemplated. They had also the Channel and Mersey Tunnels, besides others which were projected in various quarters. They might, therefore, appropriately describe this as an age of tunnel and canal cutting. The Chairman concluded by again acknowledging the kindness of the gentlemen who had ministered to the gratification of the visitors during the day.

Colonel BEAUMONT responded. He said: With reference to myself Mr. Waddell and Mr. Prentice, with whom I have been more intimately connected, I need hardly say for each of us that we have been glad to welcome so distinguished a company of visitors. Mr. Waddell is a contractor of considerable eminence, who brings a large amount of skill and ability to bear upon the somewhat difficult tasks

which he takes in hand, and this Mersey Tunnel is perhaps as difficult a one and as original a piece of work as he has had to cope with. His representative, Mr. Prentice, very energetically carries out the various duties that are entrusted to him. With reference to the importance of the work itself, you, gentlemen, have had perfect opportunity of judging. I have no hesitation, however, for myself, in saying that the work of piercing a tunnel under the Mersey is practically now an assured fact. Some year and a half ago, when the work was commenced, there were many who thought that water would come in, that there would be trouble with the strata, and a variety of other difficulties to be contended with; all of which, I am glad to say, have no existence. Curiously enough the driest part of the strata we have penetrated is that portion which lies under the river. I leave geologists to say why that should be; but my explanation, given with hesitation as knowing little about scientific geology, is that the rock itself is impervious, and the only danger to be apprehended from water is from such as may percolate through the crevices. No crevices exist which would connect the river with the tunnel; but crevices do exist connecting the beds of rock through which the tunnel has passed with the land on the Birkenhead side; that is to say, that the inclination of the strata is from Birkenhead towards Liverpool; and the whole infiltration of water that we have to deal with is due to the water which finds its way through the inclined cracks in the strata. Consequently, the possibility of accomplishing this great work turns now entirely upon whether there does or does not exist a fissure in the strata so great as to form a direct communication between the waters of the Mersey and the tunnel underneath. Nobody can say, until the first heading is put through, whether such a fissure does or does not exist; but all the evidence that we have points to the

probability of the rock continuing, in what remains to be done, similar in character to that which has already been perforated. I heard to-day what a little surprised me, that the captain of the Alaska, whom you visited, was alarmed because he heard a shot which was fired in the tunnel below him. A comparatively small explosive charge, fired under the bed of the river, so shook the strata and communicated its motion to the water as to make itself decidedly felt by the captain of the Alaska. That it was an undesirable thing to blast so near the bed of the river I had no doubt; but that my judgment should have received to-day so complete a vindication I really did not anticipate; it seems to me certainly to point to this, that any system by which the tunnel can be completed without the use of explosives must at any rate—putting other questions aside—commend itself as the prudent course to take. An experiment has been made in the hard sandstone of the Woodhead Tunnel, on the Manchester, Sheffield, and Lincolnshire Railway, which it is proposed to double, and the result of that experiment was to show that the cutters could deal with the rock perfectly—that there would be no difficulty in cutting rock of that hardness; but that the machine, which you have to-day seen, was insufficiently strong. It therefore becomes a question merely of constructing a machine of sufficient strength. When that has been done—and it shortly will be done—the question will have been solved whether it is practicable to use these machines in collieries and in driving stone drifts of a similar character. I venture to think that if this machine results in enabling dynamite and explosives to be dispensed with in the driving of long drifts in collieries, the invention will have considerable importance, especially in those mines where danger from fire damp is to be anticipated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL. XVII. SESSION 1883-84.

The ORDINARY MEETING of the Members of the Society was held on Tuesday, the 13th day of November, 1883, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

EDWARD PILKINGTON, Esq., J.P., President, in the Chair.

The PRESIDENT, upon taking the chair, said: Gentlemen, the first thing I have to do is to thank you for having chosen me as your President for the ensuing year. I am sure, if the office had been offered me on account of any supposed merits of my own as a geologist, I should have had to refuse it, my acquaintance with geology being, I am afraid, contemptible when compared with the reputation of some of those who have preceded me. But I have ventured to accept the honour more as a miner than a geologist. I think that the combination we have in this Society of geology and mining is by no means a bad one. Mining owes a great deal to geology, and geology, on the other hand, owes very much to mining. I think we shall all agree upon that point. It is, therefore, more as a miner than as a geologist that I have ventured to become your President. I hope you will accept me, and show me that forbearance which I am sure, being so young a President and so ignorant

a geologist, I shall require. Our first business will be to pass a resolution of condolence with the widow and family of the late Mr. J. F. Seddon, who lost his life by an accident shortly after the explosion at Accrington. The Council have met this morning, and have adopted a resolution in which they express their deep sympathy with the widow, and their admiration of Mr. Seddon as a man who died doing his duty so nobly.

Mr. CLEGG LIVESEY said he thought all present would be acquainted with the circumstances under which Mr. Seddon met his death; and he was sure they would feel that, having been engaged in a work that was arduous and attended with much danger, the event was a peculiarly sad one. The members would all sympathise with the resolution he had to move, which was:—

"That the members of the Manchester Geological Society tender their sincere sympathy with the widow and family of their colleague, the late Mr. J. F. Seddon, in their bereavement, and also express their high sense of his efforts to preserve the lives of his fellow-men."

The resolution was unanimously carried, and the Hon. Secretaries were instructed to send a copy of it to Mrs. Seddon.

NEW MEMBERS.

The following gentlemen were duly proposed, and upon being balloted for were unanimously elected ordinary members of the Society:—

JOSEPH CRANKSHAW, Montcliffe, Horwich, near Bolton.

JONATHAN HALL, Clifton Hall Collieries, Clifton, near Manchester.

GEORGE HENRY PEACE, Monton Grange, Eccles.

FRANK MURRAY STILL, 3, Queen Street, Cheapside, London.

ON THE MARSAUT SAFETY LAMP.

By Mr. Joseph Dickinson, F.G.S.

It was through the courtesy of the Institution of Civil Engineers that the Author's attention was drawn during the recess to a notice of a translation and abstract by Mr. Alfred Bache, B.A., Assoc.Inst.C.E., of a Paper on Miners' Safety Lamps by Monsieur J. B. Marsaut, Engineer-in-Chief of the Bessèges Collieries, Gard, in the South of France; and it is through the kindness of M. Marsaut himself that one of his safety lamps, made by Messrs. Mulkay frères, 21, Rue Rouleau, Liège, Belgium, is now exhibited.

The Marsaut safety lamp in its present improved form is in general shape and construction similar to the Mueseler, but the small horizontal disc or annular diaphragm of gauze, which supports the chimney in the Mueseler, is done away with, and it and the chimney are replaced by an inner vertical gauze in the Marsaut and the entire double gauze is shielded by an external sheet-iron casing, having inlet holes below the bottom for air to enter the lamp, and outlet apertures at the top.

Additional safety can be secured by further covering the flat top or cap of the inner gauze with a gauze hood, so as to double the thickness of gauze at that part upon which the force of an explosion inside the lamp comes most direct, or a third complete cylinder of gauze may be added, if desired, as an extra precaution; but two cylinders are considered safe enough, and are preferred generally.

The lamp is $9\frac{1}{2}$ inches high. It unscrews at two places, forming a bottom part $3\frac{7}{8}$ inches broad by $1\frac{1}{4}$ inches high, a middle part, or cage, the same breadth by $2\frac{1}{4}$ inches high, and a top part 5 inches high.

The bottom part has the reservoir for oil, which terminates $\frac{3}{4}$ of an inch from the base, and leaves space for the lower end of the pricker; and there is a flat wick, and a screw lock.

The middle part is the cage, into which the glass and gauzes are fitted. The upper rim is connected to the lower by 6 uprights, which also protect the glass, each being about $\frac{1}{16}$ inch in diameter; and in the upper rim there are 18 vertical air holes, each $\frac{1}{16}$ inch in diameter, to allow air to pass into horizontal inlets between the top and middle parts of the lamp. Fitting into the inside of this cage, and resting upon the oil reservoir, is the glass, surmounted by two wire gauze cylinders. The glass is $2\frac{1}{16}$ inches high by $2\frac{5}{16}$ inches in diameter, and $\frac{1}{16}$ inch in thickness. The bottom of the glass fits into a brass ring, with a base and side; and the top of the glass rests against 2 flat or expanding iron washers, which support the gauzes above the glass, the junctions being encased in copper caps, which fit inside of a rim that forms part of the cage. The gauze cylinders have a mesh of 934 holes per square inch, or $30\frac{1}{2}$ per lineal inch (the "Davy" being, respectively, 784 and 28), and each gauze cylinder has a gauze top. The outer gauze cylinder is $4\frac{1}{4}$ inches high, and the diameter $2\frac{1}{16}$ at the bottom and $1\frac{13}{16}$ at the top. The inner gauze cylinder is $\frac{1}{2}$ inch shorter; and it tapers a little from the outer one upwards, so as to leave a space of about $\frac{3}{16}$ inch all round at the top, or enough to admit of the inner gauze and its projecting cap being drawn easily out of the outer gauze. Each gauze has a copper ring both at the inside and outside of the gauze at the bottom, and underneath are the two washers which rest upon the glass.

The top part of the lamp consists of a sheet iron casing with a sheet iron cap, which is fixed to an outer rim at the bottom, the height of the whole being 5 inches. The iron casing is $2\frac{13}{16}$ inches in diameter at the bottom and $2\frac{5}{16}$ at

the top, and it has 9 outlet apertures oval at the bottom, and each half an inch wide and $\frac{1}{16}$ high. The bottom rim has six projections, which rest upon the upper rim of the middle part of the lamp, so as to leave six side inlets for air; each of these inlets is $1\frac{1}{16}$ inches long by $\frac{1}{16}$ high, and they are all open to the 18 vertical air holes which are below, in the top rim of the middle part of the lamp. Inside this bottom rim, with a space $\frac{1}{16}$ inch wide between, is a crown which is fastened to the outer rim at six places. This crown serves for screwing the top to the middle part of the lamp, and also for directing the inlet air upwards in a line with the outside of the outer gauze, which, with the sheet iron casing, prevents entirely any air impinging upon the gauze.

The advantages claimed for the Marsaut lamp are that it seldom goes out when tilted, and not at all in an upward current of air, nor does it explode externally a strong current of gas blowing upon it in any direction whatever. It does not fire an explosive still mixture of air and lighting gas, as has been proved by upwards of twelve thousand trials at Bessèges, when most of the other lamps in use did so, the Belgian Mueseler included. The outside casing effectually protects the gauze from getting injured, clogged with dust, or splashed; and whenever the lamp explodes inside, the casing retards the escape of the burnt gases, which thus help to put the lamp out. By covering the outlet holes in the casing, the lamp can readily be put out whenever desired.

The only inconvenience noted by the French Fire-damp Commission, in 1882, when recording their high commendation of the Marsaut lamp, was that the sheet-iron casing prevents its being seen at a glance whether the lamp is all in proper order inside. Both gauzes, however, can be taken out, and all parts of the lamp can be examined separately.

In the trials made of the Marsaut lamp at Bessèges, an

explosive mixture was employed of air and of lighting gas, which latter fires more readily than fire-damp; and the wick being reduced below its usual flame, the conditions were thus more trying than are met with undergrouud. With three forms of the Marsaut lamp, testing two lamps of each form, upwards of six thousand trials failed to produce a single external explosion, whereas fifteen Belgian Mueselers, tested simultaneously, each of them about a hundred times over, let the flame pass through the horizontal gauze diaphragm in 31 per cent. of the trials, and in 2½ per cent. produced explosion outside the lamp.

Still severer trials were also made, by mixing air with lighting gas in their most highly explosive proportions, and exploding the still mixture inside the lamps by an electric spark. Under this excessive test, the large Davy lamp used in the Gard district exploded the mixture outside it every time; the Boty, Clanny, and Belgian Mueseler, and the Marsaut lamp with two gauze cylinders, almost every time; but twelve trials of the Marsaut with three gauzes, and ten of the fire-trier's Davy, gave not a single explosion outside. These tests, and the one preceding, point unmistakably to the desirability of reducing to the utmost both the total internal volume of a safety lamp, and also the height of the glass, since the blind space inclosed by the glass acts like a cannon in propelling the inside explosion violently against the gauze, and so driving the flame out through it. The great effect which the height of the wick in the glass has was proved by these experiments, a variation of less than 0·4 inch in the Boty lamp being sufficient to produce or prevent explosion outside. The trials also show that the Davy of small diameter, still used in England by the fire-trier, but abandoned in the Anzin and Bessèges collieries, presents important advantages, and if sufficiently protected against strong currents would possess a high degree of safety.

Investigating experimentally the mesh and shape of the wire-gauze cylinder, M. Marsaut concludes that, for the same total area of apertures per square inch, gauze of finer mesh is safer than a coarser and heavier make. The lamp should be made inside as nearly cylindrical as possible throughout its entire height; and in particular the bottom of the gauze should be flush with the inner circumference of the glass. Any narrowing at this part, by the insertion of a horizontal annular diaphragm projecting inwards, or by contracting the gauze cylinder to a smaller diameter than the glass, is objectionable: doubtless because the explosive mixture inside the lamp gets thereby so churned up as to augment enormously the rapidity with which it explodes, enabling the flame consequently to pass out through the gauze.

The comparative lighting power of the various lamps tried by M. Marsaut was found to be as follows:—

ENGLISH STANDARD SPERM CANDLE of six to the pound, burning 120 grains per hour, being 100—

1. Westphalian . . .	77	8. Mueseler, Belgian .	49
2. Boty	72	9. „ English .	44
3. Westphalian . . .	70	10. Bainbridge . . .	39
4. Marsaut	69	11. Davy, Dubrulle .	32
5. Williamson	56	12. „ Gard . .	22
6. Thomas	53	13. „ Newcastle	20
7. Clanny	52	14. Stephenson . . .	17

In the Westphalian lamps, Nos. 1 and 3, the air inlet is through a collar of perforated sheet-iron all round the neck, below the bottom of the glass; No. 3 was protected by the addition of a layer of wire-gauze inside the perforated collar, but No. 1 was without this protection.

The lighting power seems to depend partly upon the metal of which the lamps are made, a brass lamp being found to

give only 70 per cent. of the light obtained from the same make in wrought iron. The difference is no doubt connected with heat-conducting capacity. English lamps are generally made of brass, and German of wrought iron. M. Marsaut is inclined to think steel, or perhaps malleable cast iron, would be advantageous.

Ten years ago M. Marsaut's own experiments led him to modify the Mueseler lamp, by discarding the diaphragm while retaining the chimney; a sheet-iron casing was also added outside the gauze cylinder, to prevent flame from passing outwards through it when exposed to a current of fire-damp; and a moveable ring was fitted round the circle of the air-inlets, for closing them all simultaneously so as to extinguish the lamp.

Renewing his efforts at improvement, M. Marsaut lately entered upon a further extensive series of experiments at Bessèges. He tried numerous safety-lamps, of which the following is a bare enumeration:—The Mueseler, of Belgian and of English pattern, with several other varieties; the original Marsaut lamp of 1871, and several varieties of its present improved construction; the Davy, of Newcastle; Gard, and Dubrulle patterns, the fire-trier's, and the "tin-can"; the Stephenson, Williamson, Clanny, Bainbridge, Evan Thomas, Upton and Roberts, Birckel, Boty, Westphalian under two forms, Rosenkrantz, Combes, and Cosset-Dubrulle.

The practical conclusions derived from these experiments are summarised as follows. With the large Davy lamp used in the Gard district, and with other lamps of the same kind, an explosive still atmosphere outside is fired by an explosion inside the lamp. The addition of a second gauze cylinder to these lamps diminishes considerably the frequency of outside explosions, but is powerless to prevent them. The flame seems to pass out through the cap of the gauze cylinder, rather than elsewhere; whence it is well to add another layer

or two of gauze at this weak part. The outside atmosphere is more readily fired by explosion within a lamp in which the wick is burning low; the prevalent practice of lowering the wick on encountering fire-damp is consequently objectionable; it is better to remove the lamp slowly, keeping the wick at its usual height. Large lamps are more dangerous than small ones, because the volume of explosive mixture they contain increases as the cube of their size, whilst the area of gauze or of outlet for the flame to pass through increases as the square only. The glass cylinder in the Mueseler and other lamps, though giving a better light, renders the explosion inside more violent, because the explosive mixture is thereby more confined, so that the lamp becomes a sort of minature cannon; the glass should therefore be kept as small as possible, particularly in height. The Belgian Mueseler, considered the safest lamp in use hitherto, sometimes explodes a still atmosphere of fire-damp outside it. Lamps with glasses are dangerous when the wick burns low, for the same reason as the Davy; in the Mueseler particularly the flame can then more readily pass up through the chimney, and so get to the upper side of the gauze diaphragm. The plan long in vogue at the Bessèges, of ascertaining the presence of fire-damp by measuring the elongation of the lamp's full flame, is safer than reducing the flame to the utmost for the purpose of seeing the blue cap of gas better; the elongation of the flame is almost always a sufficient indication. When a glass lamp is lifted up into an explosive atmosphere, it should be held there steadily till it goes out, especially in the case of lamps having their air-inlet at top; instead of being immediately withdrawn again, as would intuitively be done either through fear or to keep it alight; for a downward movement seems to have the effect of churning the gas inside the gauze, and so rendering its explosion more violent and thereby more dangerous. It is particularly dangerous

for a lamp to get suddenly filled with explosive mixture by a current blowing the flame against one side, or for the lamp itself to be tilted in such an atmosphere; any arrangement for checking undue access of gas to the lamp is a safeguard. The whole of the air-inlets should be protected by at least a double layer of wire-gauze, even in the Mueseler lamp with its chimney, which latter does not always isolate the flame; then, if the inner gauze ever gets red-hot, the outer still serves as a protection. The confined space inside a lamp should be kept as small as possible; but the gauze, which cools down the gases passing out through it when the lamp explodes inside, should present as large an extent of surface as can be; hence lamps are not to be relied on which have a tall glass surmounted by a dwarf gauze, such as the big Cosset-Dubrulle, the Bainbridge, and others like them. Lamps should be made of as small diameter as possible, and should carry as large a flame as they can without getting too hot; the aim should be to make a lamp as much as possible like a mere chimney. In glass lamps with air-inlet at the top, the wick-holder should be tall enough to raise the flame as high as can be inside the glass; a neutral space is thus left in the bottom of the lamp, whereby the force of an explosion within the lamp is mitigated. A chimney in a lamp is attended with more or less risk. The slightest modification in form or arrangement of a lamp may make a considerable difference in its safety.

The Author may observe that M. Marsaut's conclusions that the elongation of the flame is almost always a sufficient indication of gas, without allowing the gas to explode in the lamp, and that no lamp should be withdrawn quickly when testing, are in accordance with careful practice; but that his deduction that testing for fire-damp with the lamp's full flame, and judging only by the elongation of the full flame, is safer than by reducing the flame to the

utmost, for the purpose of seeing the blue cap of gas better, will be a surprise to many persons. The latter, however, is supported by M. Marsaut's reasoning that lamps should be of as small diameter as possible, and should carry as large a flame as they can without getting too hot, the aim being to make the lamp as much as possible into a mere chimney, with proper arrangements for checking undue access of gas.

Both the Smethurst and the Ashworth safety lamp, which were brought by the Author before this Society during last session, have an external sheet-iron casing to protect the guaze, like the Marsaut. The principle of such a casing, however, the great value of which in point of safety is now becoming fully recognised, is not new, it having been introduced more than a quarter of a century ago by M. Eloin in the lamp which bears his name.

It is incidentally mentioned by M. Marsaut that, in the course of the experiments, it was demonstrated that the electric spark is essentially dangerous in fiery mines, which should be borne in mind in any attempts to introducc electric lighting in colliery workings.

Since this Paper was read before this Society the Author, through the kindness of Mr. J. T. Green, manager of Celynen Colliery, Monmouthshire, on the 27th November, had the Marsaut safety lamp tested on the apparatus there, by putting the lamp into the tube or pipe and exposing it to quick and varying currents of an explosive mixture, of lighting gas; nearly all the six series of tests being made three times, with the following results:—

1st Tests.—The Marsaut lamp, as sent by M. Marsaut and as described in the paper, went out, but gas continued burning under the gauze. A Celynen Mueseler lamp, tested at the same time, went out entirely. The Celynen has a shield about 2 inches in depth around the bottom of the gauze cylinder, resting on the top ring over the glass, and

has also a strip of tinned iron, about $\frac{1}{4}$ inch broad, strapped round the part of the chimney close to the underside of the gauze disc or diaphragm, which strip projects $\frac{3}{16}$ inch at one side, to prevent gas burning underneath the disc in explosive currents, as described in Mr. Green's paper read before this Society in February, 1883.

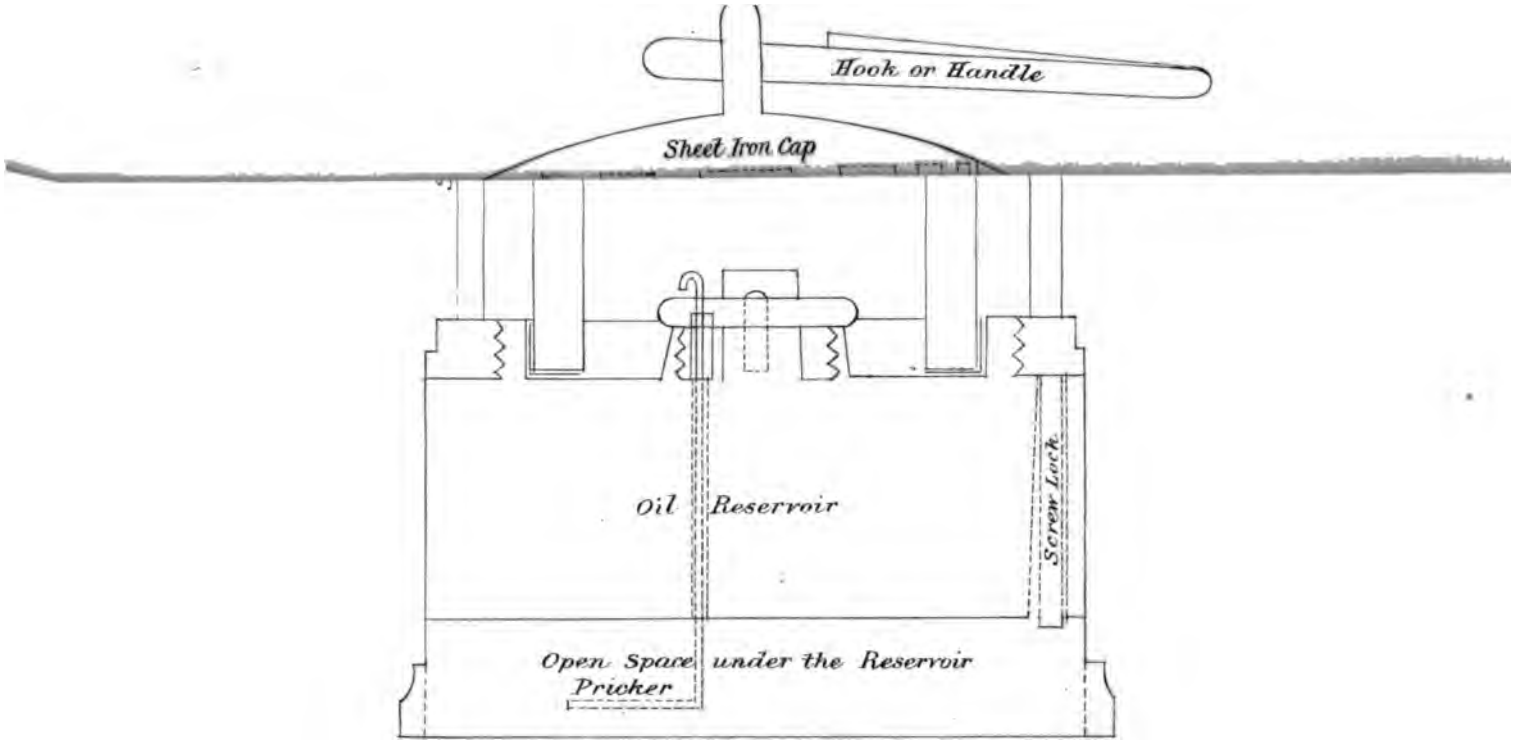
2nd Tests.—The Marsaut, with the addition of a strip of tin plate about $\frac{1}{4}$ inch in width, placed from the top to the bottom against the inner side of the inner gauze cylinder, the lamp went out as before, but gas continued burning under the gauze as before. The Celynen Mueseler went out entirely.

3rd Tests.—The Marsaut, with the addition of a strip of safety lamp gauze dividing entirely the inner gauze cylinder from top to bottom, the lamp went out, but gas continued burning under the gauze, as before. The Celynen Mueseler went out entirely.

4th Tests.—The Marsaut, with the addition of a third gauze cylinder placed outside the two other gauzes, the lamp went out, but gas continued burning under the gauze as before. The Celynen Mueseler divested of its gauze cylinder, but in other respects as before, went out entirely.

5th Tests.—The Marsaut, with the outlet apertures at the top of the outer casing so covered as only to admit of the lamp burning freely, went out, but gas continued burning under the gauze as before. The Celynen Mueseler and an Evan Thomas lamp went out entirely.

6th Tests.—The Marsaut, with the outlet apertures covered as in No. 5 tests, and with all the side inlet holes covered, and also with about one half of the inlet space at the top of the crown or inner rim covered—all the air having to come up the vertical holes, and just enough air allowed for the lamp to burn brightly—the lamp went out, and then with one flash of gas under the gauze it went out entirely. The


Hook or Handle
Sheet Iron Cap
Oil Reservoir
Screw Lock.
Open Space under the Reservoir
Pricker

Celynen Mueseler and the Evan Thomas also went out entirely. This was repeated three times with the same results.

About twenty tests were made. In none of them did gas fire outside the Marsaut; but in those tests where gas continued burning underneath the gauze, and where it so burned for about half a minute without going out, it seems probable that it would have fired through if the test had been continued long enough.

These tests, which the Author saw made, show indisputably that if the Marsaut lamp is to be used where it may be exposed to a current of explosive gas, a change in the construction will be required. M. Marsaut has tried a moveable ring for closing the air apertures, so as to extinguish the lamp. A ring for this purpose would enable a person in an emergency to extinguish entirely the lamp as at present constructed; but unless he closed the apertures gas would still continue burning underneath the gauze, and might fire through eventually in an explosive current. To be safe, therefore, and independent of any such closing having to be done in an emergency the lamp should be self-extinguishing. To ensure this, the experiments, which the Author saw made, show that the inlet and outlet apertures should be only so large as to admit of the lamp burning freely, and that apparently the whole of the inlet should be up the vertical holes, without any through the side inlets; and that the outer casing should not be removable, as it is now, but should be fixed either to the cage or be locked. The lamp with the size of the inlet and outlet apertures thus limited loses some of its advantages. It at first burns dimly if the casing is put on cold, but that is overcome in a few moments as the casing becomes warmed. The light then given is good, but not quite equal to that with the large apertures; and it goes out more readily when tilted. Apparently some drawback of this kind is inseparable from a good and safe lamp.

Based upon these trials, a lamp on the Marsaut principle, but with smaller inlet and outlet air apertures, and with the outer casing fixed to the cage, has now been made by Mr. Teale for Mr. Macalpine, with the view of such a lamp being used in the Altham Colliery, and it has been kindly tested by Mr. J. T. Green on the apparatus at Celynen Colliery. Mr. Green, on the 12th December, reports as follows:—"I have severely tested the lamp, and find that while there is sufficient ventilation, it goes out quickly in sharp currents of gas and air, and, in fact, acts in a satisfactory manner. I see one objection to the casing being *fixed* to the lamp, and it is this. Occasionally we find that in pushing the gauze up home the bottom flange of same becomes a little displaced. In the present modified form this could not be observed, and I think a valuable addition would be made to the lamp by fixing a male and female screw on ring and bottom of case respectively, so that an inspection of the gauzes may be obtained *after they are up in their places*, by simply unscrewing the case and pushing it upwards."

THE USE OF LIME CARTRIDGES AS A MEANS OF BREAKING DOWN COAL.

By Frank M. Still.

It is the object of the writer of this paper to give a brief description of a method of breaking down or getting coal, by means of lime, invented by Messrs. Sebastian Smith and Moore, of the Shipley Collieries, Derbyshire.

The consideration and study of explosives is, perhaps, of all things, most worthy the attention of those connected with mining coal, and it is, at the present time, the more so, owing to the increased necessity for economy in working that mineral, and to the feeling there is in favour of the abolition

of explosives, due to the many dangers which only too often follow their use.

In consequence of a serious explosion which occurred at the Shipley Collieries in 1857, resulting in the loss of many lives, and much damage to the mine, the use of gunpowder was strictly prohibited there, and it was in consequence of the very considerable commercial disadvantage at which the owner was placed by having to "wedge," that Messrs. Sebastian Smith and Moore commenced their experiments with the view of so utilizing the expansive power of lime as to render it an efficient agent for breaking down coal.

The result of their experiments have been most successful, the lime system as invented by them having many advantages, among which may be enumerated the following:—

1. Absolute immunity from danger of explosions of gas.

2. Greater safety in the working places, as it is unnecessary for the workmen to retire whilst the charges are being exploded.

3. A very much greater percentage of round coal.

4. Economy of timber, as the roof is in no way effected or shaken.

5. It enables the collier to work without the laborious process of breaking down the coal by wedges, and thus enables him to avoid the numerous accidents consequent on their use.

The lime cartridges are manufactured in the following manner:—

Nearly pure carbonate of lime is used—that in present use contains about 98·40 per cent. of pure carbonate. The stone, after being calcined, is ground to a fine powder, and compressed in a hydraulic press (invented by Mr. Sebastian Smith). The die in which the cartridges are formed, is $2\frac{1}{8}$ inches in diameter and 7 inches in depth. A pressure of 40 tons is applied simultaneously to both ends of the column of

ground lime, which reduces it from 7 to 4¼ inches in length—thus nearly doubling its density. A groove, ½ inch in diameter, is formed in the side of the cartridge, by a projection in the die. The cartridges are then wrapped in paper, packed in specially constructed air-tight boxes, and are then ready for use in the mine.

For drilling the holes, a light boring machine is used; the depth, distance apart, and number of the holes varying according to the hardness of the coal, but more particularly its "parting" from the roof. It may, however, be stated, that the average depth of the hole is 3 feet 6 inches, and the distance apart 4 feet 6 inches.

The holes, having been drilled (the time occupied being from twelve to twenty minutes), they are charged in the following manner:—

The first cartridge having been placed in the back of the hole—groove uppermost, a tube, having six perforations in its length (about 4 inches apart), is inserted, and laid in the groove referred to—but not quite to the back; this being for the purpose of allowing the water to reach the end. The remaining cartridges are then placed up to the first, and the hole is tamped or stemmed up in the usual way—about 9 inches of tamping being used. The charge usually consists of seven cartridges. The tubes are each covered with a calico bag, to prevent the holes being choked, and are provided with steam taps.

After charging the holes, a quantity of water is forced in by means of a small hand pump, with a light hose; the tap at the end of the tube is turned off, and the hose disconnected.

The generation of steam and expansion of the lime, commences almost immediately the water reaches the cartridges; the time taken by the lime to bring down the coal varies,

according to the hardness and position of the seam, from fifteen minutes to three-quarters of an hour.

The following results of some experiments made on the 30th and 31st October last, at the Norley Colliery, near Wigan, may be of interest; and taken as a fair average of the cost and advantages that accrue, consequent on the use of lime as a means of coal-getting.

The tenacity and hardness of the Wigan 5ft., 4ft., and 9ft. mines is so well known in the district that it is unnecessary for me to refer to them here.

	Length of Face.	Holing.	No. of Holes.	Cost of Labour and Cartridges.	Coal got.	Cost per Ton.
	ft. in.	ft. in.		s. d.	ton. cwt.	d.
Wigan 5 ft.....	10 0	5 0	2	* 1 8	6 17	2·92
,, 6 ft.....	30 0	4 0	4	* 4 6	9 16	5·51
,, 6 ft.....	12 8	4 3	1	* 0 10	5 19	1·68
,, 6 ft.....	11 6	3 4	2	* 1 10	5 15	3·96
,, 4 ft.....	17 7	3 5	2	* 1 11	7 7	3·13

Average cost per ton, 3·40d.

REMARKS.—I understand that in each of these experiments about one-third more round coal was produced by the use of the lime than by powder.

In practical every day use I venture to think that this estimate is excessive, as the only item which is in any way damaged by constant use is the drill, and, even as applied to the Wigan mines, I do not think the blade of the drill would be blunted to such an extent as to justify an expenditure of 2d. per hole.

The lime cartridges have lately been tried with some success in breaking down the roof in the gateway, and in Derbyshire the cartridges are being increasingly used for this purpose; but I may say that the cost of the ripping with the lime as compared with gunpowder is a little greater, although, as opposed to the wedge, a very great saving is effected.

* In the above costs Mr. Longbotham, the manager, has estimated the cost for the use of drills and other necessary tools at 2d. per hole.

It has been stated that the heat produced by the slacking of the lime is sufficient to ignite gas, and no doubt this is a most important point if it were so, but Sir Frederick Abel, one of the Royal Commissioners on Accidents in Mines, has, after experiments made with the view of ascertaining the truth of this assertion, expressed himself that this is impossible, since the maximum heat produced by the slacking of the lime is 700 degrees, whereas it takes a temperature of no less than 2,000 degrees to ignite gas.

In conclusion, the writer would venture to express the opinion, formed after experiments in many of the mines of the Wigan district, that the lime process is adaptable, and would be of advantage to a great number of collieries, in consequence of the great saving in round coal that would be affected by its use; but the claim which, of all others, the Patentees put forward with the greatest amount of pride is, that the use of lime as a means of coal-getting carries with it that all-important fact, absolute immunity from explosions of gas, and that fact alone, in the face of the calamities of which we read every day, should make the lime system worthy the attention of all connected with mining coal.

Mr. WOODWARD said that Mr. Still in a short space of time brought before them many points of considerable interest. One of the chief ones was in relation to the safety of lime, as compared to the use of ordinary explosives. The question, however, was as to the time taken to break down this coal, and whether lime could be depended upon in all cases.

Mr. LONGBOTHAM observed that with regard to the length of time which the coal took to fall, after a lime cartridge had been put in and charged with water, it really mattered very little, because he assumed the collier, on going into his

place in the morning would withdraw the sprags which had been left in over-night and allow the worked coal to fall, and after filling it up would hole his place and nick it in the side, and afterwards drill and put in his shot and sprag his top coal in order that, during the night, the lime might do its work. He thought Mr. Still by his efforts in this matter was trying to do a service to humanity, and deserved encouragement.

The PRESIDENT said, that of course the lime cartridges would only come into use in collieries where powder was prohibited. Lime was not meant to supersede powder; it was only intended to be used where the use of ordinary explosives was attended with danger. If it came to be a question of pounds, shillings, and pence, lime of course could not compete against powder; but in a dangerous mine, where it was absolutely necessary to use something else than powder, the lime cartridge was a most promising invention. Rather than ask what length of time was taken for the coal to come down, he would enquire—was its coming down as certain as when gunpowder was used? Because, if a man put the lime cartridge in over night, and found next morning that the coal had not come down, he would lose a whole day's work.

Mr. BURROWS pointed out that the advantage to the miner of the lime cartridge, as compared with gunpowder, was, that it might be used at any time. The cartridge might be exploded as soon as it was ready,—though he hardly knew that this mattered much in long wall working.

Mr. G. WILD said there was one other objection to lime cartridges being used during the night. A man might come next morning and find not only the coal down, but the roof as well. In that case he would want a few props.

Mr. CLEGG LIVESEY thought Mr. Wild's criticism was hardly legitimate, because there was no reason why the lime cartridges should not be used in the day time. There was

nothing to prevent them being used when everything was ready. His own opinion was that lime might be more advantageously used in a tolerably thick mine, but in a thin seam the expense would, perhaps, prove too great.

Mr. LONGBOTHAM said he did not mean in his previous remarks to imply that there was any special advantage in the coal not coming down at once, but only that it was no great disadvantage. In the experiments which were made with lime cartridges at Norley Colliery, the coal fell within an hour, as a rule, of the time that water was pumped on to the cartridge. The seam was a very hard one. In one place, in the Wigan 6ft. mine which was only 3ft. 10in. thick, and 12ft. wide, one shot was put in, and the coal, about three tons, was brought down within three quarters of an hour.

Mr. TONGE said, in answer to the President's question, as to whether the coal always came down on the application of a lime cartridge, he might say that it did not, though with a little experience, it might perhaps almost always be made to come. In their short experience of the process at Hulton Colliery, they had not succeeded in getting it down in every case; but they were quite of opinion that lime was of great advantage on the score of safety—it could not set fire to gas—and it was also advantageous as far as the roof was concerned. Another great advantage as had already been pointed out, was that it could be used at any time. In that respect it was a decided step in advance. From the experiments at their collieries his conclusion was that lime was not nearly so efficient as powder, but there was no doubt that it soon would be much nearer than at present.

Mr. STILL, in replying, said, that the lime cartridge was not intended to compete with gunpowder; it was merely put forward as the best substitute for that explosion, in dangerous mines. As to the President's remarks and question whether the lime always brought the coal down, he would

reply that, under ordinary and fair circumstances, it did do so; but, of course, it would be absurd for him to say that, for instance, in the Wigan 4ft. seam, in a place say 8ft., fast at both sides, the lime would break the coal down, and he would venture to say that there was no known means of getting coal which was applicable to every seam and under every condition. With reference to the remark made by Mr. Tonge, as to the coal not coming down, he had a memorandum in his book—made at the time of the trials at Hulton Colliery,—to the effect, that the holes in which the unsuccessful cartridges were placed, were drilled by hand, and not with the proper drilling machine. In experiments which were tried on a later date, in another seam at the same colliery, the lime was very successful, so much so, that the man who attended at the experiment said that Mr. Tonge had stated he had never seen such large coal before.

Mr. TONGE said that Mr. Still's memorandum was perfectly correct. Of course even when gunpowder was used the coal did not always come down; but there was decidedly less risk with a lime cartridge, when such was the case, than with powder.

THE ELECTRIC ANEMOMETER AND TELL-TALE,

As in Use at Garswood Hall Collieries, near Wigan.

Exhibited and described on behalf of Messrs. THOMPSON & WHITEHEAD,

By JOSEPH THOMPSON, M.E.

This communication may be regarded as a second or supplementary one, being connected with a paper which I read on the same subject before this Society, at its meeting held at Wigan, in November last. In the first paper, certain proposals were defined, which to-day are brought forward in a

practical shape; and one of the instruments referred to in the first paper is submitted for inspection. To render the matter as intelligible as possible, I have prepared the following observations:—

The name of the instrument is "Thompson's (Patent) Electric Anemometer."

Its object is,—To increase the facilities for ascertaining the quantity or volume of air circulating in the workings of coal mines, and in other situations.

Some of the more important advantages are:—

(*a.*) That by the use of this instrument, it is rendered easy for any person of ordinary intelligence to record in a book, or upon a chart provided for the purpose, either in the manager's office at the surface, or in any other selected and suitable situation, the quantity or volume of ventilation passing through the workings of any mine.

(*b.*) This form of instrument being universally admitted and proved to be the only reliable form of anemometer at present in existence its indications may be relied upon without fear of that equivocation well known to be inseparable from other forms of anemometer used in mines.

(*c.*) The lulls and impulses which are constantly occurring in the velocity of underground air currents, owing to obstructions to the free passage of the air through the air-ways, by falls of roof and other causes can be immediately and faithfully indicated.

(*d.*) The observations obtained by the use of this anemometer are not only of a perfectly reliable character, but are of what is actually going on at the moment of observation, a point of great importance considered in relation to the existing system under which the account (necessarily imperfect) of observations made is not usually presented to the manager until a considerable period of time has elasped.

(*e.*) Although extreme delicacy and sensitiveness are claimed for this instrument, its moving parts are so few and of such a character that the possibility of its becoming damaged or getting out of order is very remote, there being little or no strain upon any of them.

(*f.*) It constitutes what is now and for many years has been a great desideratum in connection with mining ventilation, being a truly reliable and scientific tell-tale of the operations of the furnace or other form of ventilating apparatus man, every slackness or abnormal increase of the ventilation being immediately observable.

(*g.*) It renders it easy (a point which will be again referred to) for the observations of all such instruments as are connected with the ventilation of mines to be effected at one point.

Description.— The entire apparatus may, for convenience, be said to consist of three parts, viz. :—Transmitter, Line with battery, and a Communicator.

The Transmitter is that portion of the apparatus which is to be placed below ground, and imports into its construction what are commonly known as Robinson's cups, being four hemispherical metal cups, with their open sides all turned the same way, and mounted at the extremities of two arms crossing at right angles and fixed upon a vertical axle, the concave sides of which, when erected, are acted upon by the wind, and the whole is thus put in rotation. In the transmitter under consideration motion is imparted to a horizontal from a vertical shaft or spindle by means of mitre gearing, while upon the horizontal shaft is placed a cam, over which rests an arm or lever, by the operation of lifting and lowering which due to the revolving of such cam, an electric circuit is complete and broken once for every revolution of the cups, the apparatus being so arranged that every revo-

lution of the cups represents the passage over them of ten lineal feet. To ascertain the velocity, therefore, of any air current it is obviously simply necessary to add a cipher to the number of revolutions in any one minute, or the average of any number of minutes, and multiply in the usual way by the predetermined superficial area at the position of transmitter, and the number of cubic feet per minute is at once determined.

The number of revolutions can be counted in the mine at the transmitting station or (by means of an electric line of wire) can be made readable at any other point or number of points either in the mine below or on the surface.

Line.—Two lines of wire should be used to form what among electricians is known as a "metallic circuit," the ordinary way of using "earth" to complete a circuit having been found to be unreliable at great depths below the surface. The ordinary "Leclanche" battery is used for the purpose.

Communicator.—This is an ordinary electric single-stroke bell, or dead-sound beater, to suit the taste of the user, and can be made to indicate constantly or intermittently by the use of a switch fixed adjacent to the position of communicator.

It is claimed, *and it is an unquestionable fact*, that this instrument is not only the first really reliable and accurate velocity indicator ever adapted for use in coal mines, but that it offers for the first time in the history of coal-mining, the great advantages previously referred to in connection with successful ventilation. With this, however, as with many other inventions, there is a tendency to regard the advantages as problematical, and the apparatus as existing only in the region of experiment. In this particular case, the question always being whether one revolution of the cups of the transmitter, as given by the beats of the communicator, did really represent the passage of ten lineal feet over them

or not. On this point, an investigation of the details of the subject would immediately satisfy the most sceptical; but it will suffice for every purpose here to state, that 10 feet for every revolution is based, first upon the information given by Dr. Robinson himself in the Transactions of the Royal Irish Academy, where he says:—"It has been determined by experiment, that the resistance on the concave is four times that on the convex, and both theory and experiment concur in establishing the striking fact, that (except so far as friction interferes) the wind moves exactly three times as fast as the vanes."

Since Dr. Robinson demonstrated this, it has been accepted by Fitzroy and other eminent meteorologists; and Mr. R. H. Scott, the present chief of the Meteorological Department at the Board of Trade, has but recently stated that it was "practically the only velocity anemometer now in use." Independent, however, of all this, I have made some extremely careful experiments with one of my own instruments, in a mine at Wigan, on the 22nd August last; the result being that the instrument gave 10 beats for the passage of every 100 lineal feet—the 100 lineal feet being defined by the passage of powder smoke, fired by electricity at the windward end of a passage of uniform area of that length.

The test was many times repeated in both high and low velocities, with the same result in each case. There, therefore remains no doubt upon this point; and it now need only be added, that one of these instruments, working in the dumb-drift of the Wigan six-feet mine, has been in constant motion by night and day for three months without lubrication, and without any apparent change or deterioration through wear or any other possibly injurious influences; and that, by an extensive experience with these cups, the Board of Trade have found them to have a long life; while obviously they must be exposed to greater severity, strain,

and oxydation in smoke over or near towns, than in many cases they would be in coal mines.

There is, moreover, another aspect of the question, which I think I ought to name, and one which must not be regarded in any sense as of secondary importance, and it is that by the use of this anemometer it is probable that much new and valuable information will be obtained, and important deductions drawn in connection with the ventilation of mines.

Anemometry now occupies a highly important place in the meteorological world, and by its aid, in connection with navigation, many highly-important results have appeared, results never thought of by the early advocates for its pursuit, and it is by no means improbable that it may, in connection with the working of deep and fiery mines, be found to occupy a position none the less important than it occupies in connection with navigation. So long as the causes of so many of our disastrous colliery explosions continue to be shrouded in mystery, so long shall we be compelled to own that there still remains something to be done, some mystery to be unravelled, and something at present partially or entirely unknown to be worked out. Whether an improved system of anemometry will prove to be a contributory means to the attainment of this highly desirable result it is of course impossible to say, but, having in view the history of meteorology (of which anemometry forms a highly important feature) in connection with the saving of life at sea, it may reasonably be suggested that it is at least an exceedingly hopeful direction in which to look.

I also submit for inspection, a copy* of a lithographed form of chart, which I have designed for use in connection with the anemometer under consideration. This chart is so arranged as to admit of a record by means of distinctive

* Copies of the chart may be obtained from Mr. J. Thompson, M.E., 8, Exchange Street East, Bolton.

trace lines of the readings of all the instruments, whose indications may be regarded as connected with atmospheric changes, such as are likely to exercise influence upon the ventilation of coal mines. The instruments coming within the scope of this chart are the barometer, thermometer, hygrometer, water guage, and anemometer. The chart has two diagrams; the upper one being devoted to the first four instruments named, and the lower one to the anemometer alone. Short notes, relative to the use of the chart, are printed on the margin. The trace lines on the upper diagram indicate the atmospheric changes; while, in a theoretical sense, the lower diagram should show what effect such changes have had upon the volume of ventilation circulating within the mine. Even in a local sense only, it is obviously of the highest importance to make and record such observations; and in cannot be said to be less important, that such should be done for purposes of inter-comparison also; and, if previous experience in the world of research may be taken as any guide, it is, in my opinion, utterly impossible even to conjecture what desirable results might be seen in connection with this important subject, before the issue was completely worked out.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XVII. SESSION 1883-84.

The ORDINARY MEETING of the Members of the Society was held on Tuesday, the 4th day of December, 1883, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

EDWARD PILKINGTON, Esq., J.P., President, in the Chair.

A letter was read from Mr. Arthur Birtwistle, acknowledging the vote of condolence which, at the last meeting, was ordered to be sent to the widow and family of Mr. J. F. Seddon.

The PRESIDENT said that, at the meeting that day, the Council had resolved that a letter of condolence should be sent to the family of the late Mr. Thomas Knowles, a former President of the Society, who died on the 2nd inst. He (the President) would move that such a letter should be sent, and that it should express the sympathy of the members of the Society at having lost so valuable a member.

The motion was unanimously agreed to.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected ordinary members of the Society:—

HENRY BANCROFT, C.E., Moor Lane, Kersal, Manchester.
ALBERT JOBLING, Spring Wood House, Burnley.
HENRY JOBLING, Spring Wood House, Burnley.

A GEOLOGICAL SECTION OF THE MERSEY AND IRWELL VALLEYS.

Mr. E. LEADER WILLIAMS, M.Inst.C.E., had undertaken to show a Geological Section of the Irwell and Mersey Valleys, with samples of the numerous borings he had taken. In his absence,

Mr. HUNTER, C.E., exhibited the section and borings. He said that Mr. Williams's absence in London prevented his attendance, but he (Mr. Hunter) had been instructed to bring the section which had been made for the purpose of the Ship Canal, and a few samples of borings from the multitude which had been taken. He did not know that there was anything which he could say about the section. There was nothing in it calling for special observation, beyond the two singular dips in the rock—one at the upper, or Manchester end, where they found a remarkable valley in the rock, across the Salford Racecourse—and the other, an even more sudden depression, extending in depth to 120 feet within a quarter of a mile, at Latchford, near Warrington. Otherwise the section was a very ordinary one indeed, and one which, no doubt, the whole of the members of this Society would be sufficiently familiar with. He perhaps might say, from an

engineering point of view, looking at it in the light of the construction of the Ship Canal, that if the promoters of that undertaking had had the selection of the materials—had they had the arrangement of the strata for themselves—they could hardly have chosen more fitting materials, or those which would more facilitate the carrying out of the object than what were to be found in the course of the canal cutting. Almost everywhere, as would be seen from the section, the bottom of the canal was on the red sandstone—the upper Triassic—and above that was the ordinary alluvial deposit of gravel, sand, and clay, all of which could be made use of in the construction of the canal, either for concrete, or brick-making, or—in the case of sand—for mortar. There were samples of the borings, if members cared to see them, but they were so very ordinary that he had only brought them in order that those might look at them who desired. Only in one or two places did they touch the marl.

Professor BOYD DAWKINS said he could hardly agree with the gentlemen who had brought this subject before the meeting that it was a matter of little interest. It seemed to him (Professor Dawkins) that when they looked at the irregular surface in the solid rocks, which were covered up with superficial deposits, and when they had the rock presented to them in a regularly made engineering section, they were having brought before them very forcibly the actual condition of the ancient land surface, cut into hill and valley, before any boulder deposits were formed in this part of the country. The section was to be looked upon not at all as an exceptional one, but as a sample of the undulatory land surface carved in the solid rock which exists underneath the superficial deposits of clay, sands, and gravels of boulder clay origin, and of a pre-Glacial remote origin. This irregular land surface was a thing which had cost the civil engineers of this district an enormous amount

of money, for in a great many cases that had come under his knowledge they had assumed in making their calculations that the surface of the rock below was similar to the surface of the ground above, when, as a matter of fact, it was scarcely so in any case he had ever known. He had known a variation of as much as 160 feet in one short length at Rivington. The irregular contour of the rock was shown in the section now exhibited, although, of course, the vertical scale was exaggerated; and such was the surface they found everywhere in Lancashire and Cheshire underneath the superficial deposits. He would even make a wider generalisation, and say that, wherever we get the boulder deposits of sand and gravel, and the older deposits of alluvial mud, there is a surface of that kind below. This is the case in many places in the South of England—in Essex—and in the region of the Humber, where the superficial deposits amount in some places to upwards of 100 feet. He felt personally obliged to Mr. Williams for putting that section before the Society; and he hoped those data would be printed in the Society's Transactions, in order that they might be compared with the observations made in Liverpool and the surrounding district in a paper contributed recently to the *Quarterly Geological Journal of London* by Mr. Melland Reade.

Mr. HUNTER said he ought to have pointed out what had been mentioned by Professor Dawkins, that the vertical scale in the section was very largely distorted, as compared with the horizontal scale—the former being 15 feet to the inch, and the bottom 6 inches to the mile. What appeared, therefore, in the section as peaks of rocks apparently very precipitous were only ordinary inclines. The remark which had been made as to the manner in which engineers had been misled by the nature of the surface of the red sandstone rock in this district had been amply borne out by his own experience.

There was one exceptional circumstance to be noted in regard to the section: he did not think he had ever before known or heard of a case in which so much care and money had been spent upon borings in what was, in a measure, a preliminary inquiry. There had been made a complete and accurate section of the Mersey and Irwell Valley, from Liverpool to Manchester, which would doubtless be a useful record in days to come.

Professor BOYD DAWKINS said he had not the slightest doubt in the world that all this hill and valley system, below the alluvial, was pre-Glacial. This island, it must be remembered, was dry land any number of thousands of years before the Glacial period, and for the rain to have found its way down to the sea it must have left inequalities in the ground in the way presented in this section.

In reply to another question,

Mr. HUNTER said that the deepest boring was 120 feet, that was at Latchford; and even at that depth they did not find the rock. The other borings were, as a rule, from 30 to 40 feet,—one was 50 feet—and almost in every case they found the rock.

SIGILLARIA ("POT-HOLES") AND THEIR DETECTION IN THE ROOF OF A COAL SEAM BY THEIR STIGMARIAN ROOTS.

BY MR. GEORGE WILD.

The fact that the fossil known as stigmaria is the root of that abundant plant of the coal measures, sigillaria, has, by the labours of the late Mr. E. W. Binney and others, long been a settled point with geologists. The direct connection of the trunk with its roots is also no new discovery. Speci-

mens have been obtained and preserved in many of our museums (the collection presented by this Society to the Owens College notably). They have also been figured in numerous geological works. In this country the rarity of specimens with root and trunk connection has hitherto been such that few good specimens have until recently been met with, and much doubt created whether the casts of the trunks found in the roofs of many of our coal seams known to the miners as "pot-holes" were really organic casts of plants, or were due to gases escaping from the decomposing and probably liquid mass of matter forming the coal, in the form of bubbles, which, bursting, would let in the soft covering of muddy sediment or roof, forming a cast surrounded by a film of carbonaceous matter. That hypothesis may be very sparingly allowed to account for some of the irregular casts sometimes met with, but there is no doubt that other causes were in operation, playing an important part in determining the shape of the bastard pot-holes. Not intending to advance any definite opinion as to the short crumpled-topped hole from which has dropped the cast, I will briefly allude to the occurrence of the more perfect ones.

It has been my duty for a long time, as it is that of all colliery managers and underground officials, to examine the roof, the most dangerous part in many respects of most coal mines, and having taken much interest in the above mentioned phenomena, both in a geological sense and as a matter of safety, the indication of their presence has formed somewhat of a study, in order to avert danger and to satisfy myself on the scientific points. Many have been the disappointments when looking for traces of their connection with roots, only having been successful in detecting that connection very imperfectly in about three or four cases previous to the last 12 months, though I had examined hundreds of holes from which the cast had dropped, showing the com-

mencement of the root divisions, and it was with no little surprise when a nearly perfect stool of roots connected with a trunk met my observation about the commencement of this year.

In looking up at the roof, which was a little broken, two stigmaria-looking objects took my attention, which I felt certain proceeded from a stigmarian stool. A slight pull with the pick brought down the cushion or saddle on which rested the base of the trunk, and disclosed a splendid specimen with a complete set of roots, a fairly accurate sketch of which is seen in Diagram 1, fig. 1.

What is most surprising, I confess, from not having discovered them earlier, is the fact that, having once got the cue to these hitherto extremely rare fossils, five others, imperfect ones, but stools of roots nevertheless, were seen in less than a week, since which time four nearly equal to the first one, and about a dozen somewhat less perfect ones, have been seen. In the case of one, a rather large specimen, I again noticed a stigmaria pointing on the corner of a pack-wall, which was just in the act of being crushed down by the pressure of the roof. Two props had been uncapped and were receiving attention, when I called out to the men to make haste from front of it, as there would be a pot-hole on the edge of the wall. They had scarcely time to escape when the large cushion, weighing from four to five hundred-weight, on which the base rested, bore down the wall, leaving the root-bearing pot-hole still in the roof, and a very fine specimen it was, but much cracked or broken across by the settling of the roof on the gob, and another nearly similar one was found about six feet distant.

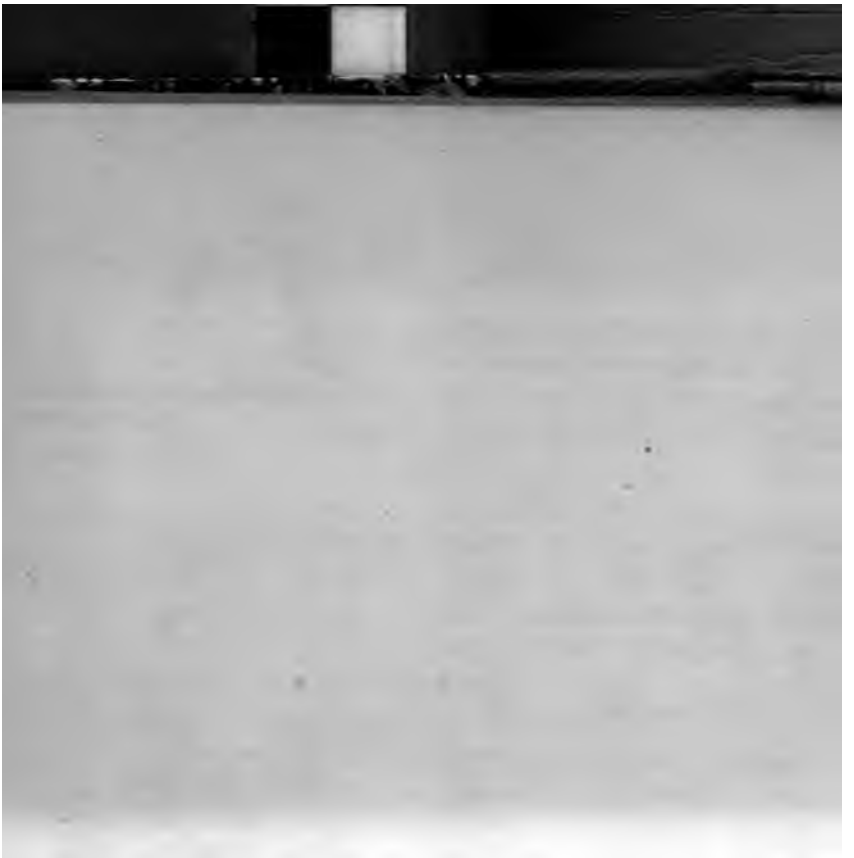
I had seen the Oldham "fossil forest," and nearly thirty years ago met with ten trunks varying from two to thirteen feet in length, in a shaft at Burnley, not more than twelve feet in diameter, and even the roof of the Old Mine at this

(Bardsley) Colliery contained many erect trunks, some of which left no doubt on my mind at the time of their being of a lepidodendroid character. But to find nearly half of these fossil forms with roots, in the roof of the Peacock Mine, is worthy of notice.

Fig. 2 is a view looking down upon Fig. 1, and showing the proportion of trunk which was broken off with the roots, and which, at 17 inches from the centre of its base, was 21 inches diameter, and coarsely furrowed on the exterior.

Diagram 2 is intended to convey some idea of the characteristic features of the roots and articulation of the rootlets externally, also the vegetable structure internally, so far as at present known, the nature of which can be seen in this slide if carefully held before the light. The rootlets are often found much longer than is shown on the diagram, having measured them in a rock seat 4 to 5 feet in length, and their presence is very often indicative of a coal seat or floor, and may have given rise to the term "warrant," used in some localities. That the growth or presence of roots and rootlets in the seat of a seam of coal has unstratified the shale, if I may be allowed the remark, most old sinkers will agree with me, especially in strong ground where planes of stratification or floor partings are eagerly sought for, to assist in making way for the measuring tape. Fig. 1 is a transverse section showing the outer and inner woody zones with the articulations of the rootlets, and Fig. 2 is a longitudinal view part solid and part in section, showing their arrangement and the general appearance of stigmaria externally, while the lower part shows the two zones of vascular tissue in vertical section. Figs. 3 and 4 are transverse and longitudinal sections of rootlets showing their internal structure.

Diagram No. 3 is a section of the seam of coal (Peacock Mine) showing the stratification of roof and floor and position



in which the before-mentioned sigillarian trunks are found. Their bases, it is seen, rest on a bed of blue shale about two feet above the seam of coal, the roots for a short distance having a downward inclination, afterwards taking a horizontal direction, and unless filled in with some harder material than the shale surrounding them, quickly become flattened, and are lost sight of among the gigantic prostrated and flattened trunks of lepidodendra, calamites, sigillaria, &c. The centre of the base rises above the horizontal roots from 4 to 12 inches, depending somewhat on the extent of downward movement of the trunk while decaying and becoming imbedded, which, from the shrunken or crumpled appearance of the bark at the junction of root and trunk, seems in some cases considerable.

Fig. 1 on the margin is a base which dropped out without breaking off more than two of the root-casts, and shows the usual sigillarian markings. Fig. 2 is a portion of another stool, or, rather, the cushion on which rested one of the four main roots, also the secondary divisions of the same, and two ridges fitting into the two sulcated lines or furrows accompanying the secondary roots.

The conclusion I arrive at is that no colliery manager can with advantage ignore geological phenomena indicative of a danger, the creation of which is in no way due to either unskilful planning or negligence on the part of anyone connected with colliery operations, and by that reason accidents arising therefrom are less likely to be avoided than most of the many to be guarded against underground. It therefore behoves us to take advantage of every means that present themselves for detecting so treacherous a foe as the hidden pot-hole, or the silently yet suddenly falling slickensides, in the roofs of coal mines. The bases of these stool-bearing trunks can be recognised not only by the roots themselves, but by the crucial and quater-

nary divisions which are seen directly under the base or pot-hole, where the stigmarian punctures are almost obliterated. Had it been possible to detect these objects by the features of the upper surface only, then no economic value would attach to a knowledge of their form further than we already possess, viz., that their separation from the surrounding strata by a film of coal and their upward taper render them dangerous to work under.

The most common form under which they are so well known requires no further description than that shown on Diagram 3, Figures 3 and 4, which leads to the conclusion that those short portions of trunks have in most cases been hollow to the level of the seam of coal with which they have become incorporated. As, often the deposit of fishes scales, teeth, spines, &c., and bituminous shale on the top of a seam, have been continuous almost evenly with the roof through the hollowed trunk, a circumstance easily accounted for when under the same depth of water as the surface of the seam and sufficiently decomposed to have become hollow.

Many objects of interest are to be met with in the roof, as well as its being that part of underground workings requiring the most attention, and assuredly it cannot be beyond the duty of the highest official to examine that part whenever opportunity occurs.

The aim of the writer is not only to bring a small contribution to science, but also to the mining interest generally in avoiding, however slightly, one or more of the greatest sources of danger attaching to coal mining, a matter of no little importance to both employer and employed; and a desire to encourage, so far as may be, the study of the flora and fauna common to, and eminently characteristic of, not only the coal-measures generally, but special horizons in those measures.

It is to be feared that the purely geological side of mining

engineering is not often duly appreciated, that the idea prevails that, because it requires only the big capitalist and skilful engineer, to lay out a successful colliery in an unbroken coalfield already proved by former operations, therefore the geology of the district is of little consequence. Occasionally that may be so, but how often do we find coalfields ventured into, the correlation of which is extremely difficult to the geologist who has studied the district, and almost a perfect blank and disastrous to the engineer who has not made that science a portion of his study. It is not only the general thickness, texture, and colour of the beds of shale, sandstone, and ironstone bands and nodules, as well as their order of superposition, but the predominating species of plant or animal remains found in them, and the character such organisms have given to the strata in which they are found, that constitute the advantages of the student of geology.

Professor BOYD DAWKINS said he had listened to the communication with great pleasure, first of all because it was an interesting communication in itself, and also because, when Mr. Wild was working out the trunk which had been described, he was kind enough to invite Professor Williamson and himself to see what was being done. They went into the workings, and saw what he was quite sure would delight the soul of any man who cared for fossil vegetation. He did not know any sight—so far as fossils went—to be compared, for one moment, with that of the roof of the Peacock Mine, for not only in some places were the remains of trees of the kind which Mr. Wild had put before them to be seen, but there were huge trunks lying amid a tangled mass of ferns, and the most extraordinary collection of fossil vegetation—calamites, lepidodendra, sigillariæ,

and stigmariæ, and other undescribed forms, all mingled together in a way which was simply marvellous. He believed the practical value of Mr. Wild's remarks to be very great. They knew that from time to time, in coalpits, very serious disasters happened, through those masses, those great columns, of rock suddenly breaking down and crushing the unfortunate miner who happened to be working underneath. It would therefore follow that when those stigmarian roots were observed radiating from one centre, as Mr. Wild had described, they were to be taken as indicating the direction from which danger was to be apprehended from the downfall of the cast of the fossil trunk. This had been formed thus. The trunk, after being submerged and partially buried, was decomposed, until there was nothing left of it but a thin layer of bark, which got filled with sand or mud, as the case might be, and the only thing that kept the cast of the interior in its place was the thin carbonaceous matter, which represented one of the original layers of the bark. He really felt exceedingly obliged to Mr. Wild for his communication, and thought that the owners of collieries would do well to lay his remarks to heart in regard to their practical application.

The PRESIDENT said he could bear out Mr. Wild's observations with respect to those trunks falling out. Every collier knew what was a pot-hole, but if they asked him about sigillarias and stigmarias he would be rather non-plussed. The men generally knew where they were, and were very careful of them; still, they could not always be avoided; and accidents sometimes happened in spite of all their care.

Professor BOYD DAWKINS: May I ask how the men get a practical knowledge of where these pot-holes are?

The PRESIDENT: Generally there is some sign of them—the thin layer of bark round.

Mr. WILD: In pot-holes of the usual form generally the cleavage of the coal, directly underneath, has been disturbed, and the miner finds that it is tough—"woody," he calls it—there is no proper parting. I have no doubt, from the shrunken character of the junction of these roots with the trunk that, while being embedded, the weight of the trunk before thorough decomposition has gradually pressed down a little into the shale. In most instances where they penetrate the coal seam I should expect to find them without the roots, but, in the case before us, the trunk has not been embedded in the coal; hence the sigillarian roots are well preserved. The stigmarian markings may, in some cases, be obliterated, but when a patch of roof falls, or is taken down, the roots are bared, and any miner can readily get an understanding of what a stigmarian root is; it is generally rather barer of other vegetable remains, and lighter in colour inside the cast than the shale around it; and if he will notice that and trace it a little he will find the direction of the root bearing towards the centre of the trunk. We are continually meeting with them now since we dropped on the proper way of looking for them.

Mr. STIRRUP said those who had the pleasure of listening to Professor Williamson's address at the meeting of the British Association at Southport would understand the value of such observations as those of Mr. Wild to one who followed out the history of plant life in the carboniferous age, as Professor Williamson had done. Mr. Wild's paper would be a valuable contribution towards settling the question now pending between certain French palæo-botanists and those of our own country, as to whether there really was any organic connection of the stigmaria with both the sigillaria and lepidodendron. The French authorities separate sigillaria from lepidodendron, while Professor Williamson

demonstrates them to be different stages of development of the same plant. He would like to ask Mr. Wild if he had ever found anything like terminal branches.

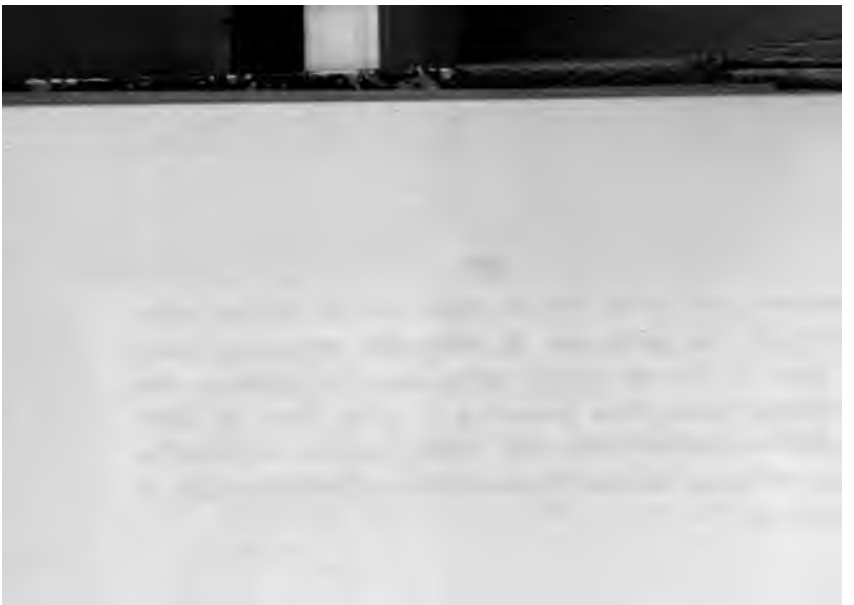
Mr. WILD: I am not aware that any true branches have yet been met with belonging to well-marked sigillarian trunks—neither to the flattened prostrate stems, nor yet the upright trunks.

MODE OF PATENT SAFETY CATCH FOR WIRE ROPE GUIDES.

EXHIBITED AND EXPLAINED BY MR. W. BROWN.

Mr. W. BROWN exhibited and described a model of a safety catch for wire rope guides, which has for its object the prevention of accidents to pit cages by the breakage of the winding rope. For this purpose levers are placed on each side of the cage, and turn on pins, and form the centres upon which the levers work. The ends of the levers are provided with hinge joints, from which extend upwards suitable rods having rollers extending outwards, with flat circular surfaces to ensure an effectual grip on the guide rods which are fixed to the sides of the cage. The opposite ends of the levers are secured by a hinge joint to connecting rods joined together above the cage by tie rods, to which a link is attached to the winding rope. When the cage is suspended the rollers are drawn away from the guide rods, and the whole weight is supported on the connecting rods as well as the pins or centres of the levers. In the event of a breakage, the whole weight of the cage is thrown upon the centres, causing the suspended ends of the levers to fall and the

opposite ends to rise with the rollers into the inclined plane and grip the guide rods, by which the cage is held, supported by its own weight acting upon the rollers in the inclined planes, thus preventing it falling down the shaft when unattached to the rope. Springs are also attached as an additional safeguard in case of the accidental breakage of the rope.



TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XVII. SESSION 1883-84.

At the ORDINARY MEETING of the Members of the Society, held on Friday, the 4th day of January, 1884, in the Mining School, Wigan;

JOHN E. FORBES, Esq., F.G.S., Vice-President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected ordinary members of the Society:—

SAMPSON GARSIDE, Colliery Manager, Denton.
JAMES ROSCOE, Colliery Proprietor, Little Hulton.
HENRY WORTHINGTON, Colliery Manager, Little Hulton.

The following are the recent additions to the Library:—

Belfast Natural History Society: Report and Proceedings, Session 1882-83; *From the Society.* Cornwall: Mining Institute—Proceedings, No. 8, 1883; *From the Institute.* Royal Geological Society of Cornwall—64th Annual Report, 1883; *From the Council.* Glasgow: Natural History Society—Proceedings, Part 2, Vol. V.; *From the Society.* Iron and Steel Institute—Journal, No. 1, 1883; *From the Institute.* Liverpool: Geological Association—Annual Report, 1883; Transactions, Vol. III., Session 1882-83; *From the Association.* Geological Society of Liverpool—Proceedings, Part 4, Vol. V.;

From the Society. London: Geologists' Association—Proceedings, Nos. 2-3, Vol. VIII.; Title Page and Index for Vol. VII.; *From the Association.* Geological Magazine, Nos 232-234; *Purchased.* Geological Society of London—Quarterly Journal, No. 156, Vol. XXXIX.; List of Fellows, November, 1883; *From the Society.* Institution of Mechanical Engineers—Proceedings, No. 3; July, 1883; *From the Institution.* Midland Institute of Engineers: Transactions, Part 49, Vol. IX.; *From the Institute.* Mining Institute of Scotland: Transactions, Parts 5-6, Vol. VI.; *From the Institute.* North of England Institute of Engineers: Transactions, Part 5, Vol. XXXII.; and Part 1, Vol. XXXIII.; *From the Institute.* Norwich Geological Society: Proceedings, Part 7, Vol. I.; *From the Society.* Palæontographical Society: Monograph, Vol. XXXII.; *Purchased.* Salford: Annual Report for 1882-83 of Committee of Museum, Library, and Parks; *From the Corporation.* South Wales Institute of Engineers: Proceedings, No. 5, Vol. XIII.; *From the Institute.* Canada and U.S. America.—Toronto—Canadian Institute: Proceedings, Fas. 5, Vol. I.; *From the Institute.* Indianapolis—Department of Geology and Natural History: Twelfth Annual Report (1882), by John Collett, State Geologist; *From John Collett, Esq.* Smithsonian Institution: Annual Report for 1881; *From the Institution.* Christiania—Royal University of Norway: Catalogue of Books received in 1880-81; Silurfossiler o 9 Pressede Konglomerater, af Hans H. Renset; Die Silurischen Etagen, 2 and 3, Von W. C. Brogger.; *From the University.* Der Geographische Gesellschaft zu Greifswald Jahresbericht, 1882-83; Der Deutschen Geologischen Gesellschaft Zeitschrift; Heft 3, Band XXXV. 1883.; *From the Society.* Naturwissenschaftliche Gesellschaft Isis in Dresden: Sitzungsbereichte, Januar zu Juni, 1883; *From the Society.* R. Accademia dei Lincei: Transunti, Fas. 15, Vol. VII.; Atti, 3 series, 1882-83; Memoire, Vols. XI.-XIII., 1881-82; *From the Academy.* Australia: Reports of the Mining Surveyors and Registrars, Victoria, (Quarter ending June 30th, 1883); *From the Secretary of State, Victoria.* "New Zealand—Its Mineral resources," by H. Bramwell, M.Inst.C.E.; *Pamphlet from the Author.* Argentine Republic: "A Statistical and Geographical Review of the Country and its resources," by Francis Latzina. Buenos Ayres, 1883; *From the Government.*

Before commencing the ordinary business the members proceeded to the Dairy Pit, belonging to the Wigan Coal and Iron Company, for the purpose of inspecting Mr. Cockson's patent Silent Guibal fan at work, getting 250,000 cubic feet of air per minute, at a water gauge of 4·9 in. They had also the opportunity of seeing a 9 ft. upcast shaft

in course of being enlarged to 14 ft., and the electric light in use for working in the shaft.

On reassembling at the Mining School, a descriptive paper was read

ON A NEW VENTILATING FAN.

By Mr. Charles Cockson, M.E.

In June, 1882, I read a paper before this Society "On Centrifugal Fans: their relative efficiency and useful effects." (See Part xviii., Vol. xvi.)

In that paper I was much assisted in arriving at my conclusions by the report of the committee of the North of England Institute of Mining Engineers on the same subject. I now beg to remind you that among the conclusions which I drew in that paper, which were, I think, agreed to and confirmed by the members present at the discussion, were the following points :—

1st. That centrifugal ventilators (or fans) are much preferable to the variable capacity or air pump type of ventilator, and 2nd. that the Guibal is a much more effective fan than the Waddle and Schiele, because of its ability to produce at a given speed of the tips of the fan blades, a much higher water gauge, and consequently under similar mine conditions a greater quantity of air than any other type of fan.

To these conclusions I had been led by numerous experiments which I had been able to make at the Wigan Coal and Iron Company's collieries on both Schiele, Waddle, and Guibal fans, and feeling so absolutely convinced of the theoretical and practical superiority of the Guibal, I began to think whether even it could not be improved in any way, particularly in the direction of overcoming the main objection to its use, namely, the great size, weight, and expanse of

fan required to do heavy work, the advocates of the Schiele fan having here a decided advantage to claim over the Guibal, as even at some colleries it would be practically impossible to put up a Guibal fan on account of the space and depth of excavation required.

With this object in view I designed and patented an improved type of Guibal fan, in the hope that it would be what I have termed it, the "Silent Guibal," that is, a fan of the Guibal type, having all its great advantages, and yet at the same time being a silent non-vibratory fan like the Schiele, and consequently combining all the good points of each type of fan, and this, I think, I may fairly claim to have accomplished.

At the time of taking out my patent the Wigan Coal and Iron Company were considering the advisability, and indeed the possibility of successfully setting a fan to work to take the place of the underground furnaces at their Dairy Pit; and on laying my plans before them they made sure of not making any mistake by having working models (50 inches in diameter) made of the improved and the ordinary Guibal. With these models a number of experiments were made which fully confirmed my ideas and proved conclusively that—

1st. The improved fan was really a silent fan without any vibration;

2nd. That under like conditions it produced a slightly higher water gauge and a little larger quantity of air than the ordinary Guibal.

On the strength of these experiments it was determined to put up one of the new fans, and instead of having an ordinary Guibal of 45 to 50 feet, as had been thought necessary to do the very heavy work required, a silent Guibal, 30 feet in diameter, was put up, and since August has been working most satisfactorily.

The Dairy Pit fan is 30 feet in diameter, has a close-fitting casing, expanding chimney, and adjustable shutter, just like the Guibal, but the blades of the fan are made to taper from a width of 15 feet at the inlet end of blade to a width of 7 feet at the tip; this tapering of the blades being so proportioned as to give an equal area of air passage throughout the fan; and it is in this that the main alteration lies, and it is owing to this that the fan is a silent one. This particular fan draws its air through one inlet 14 feet in diameter, the fan being connected to the upcast by a circular iron tube of that size. The upper half of the fan casing is made of iron plates cast to the outline of the curve of the blades, and roofed with wood lags, while the lower half and fan race and chimney are built in brickwork to the same curve. The fan itself is constructed on the usual lines; in fact it is the framework of a Guibal fan, which the company had on their hands.

Such is the fan, and it was put up to produce five inches of water gauge, and to be able to pass 300,000 cubic feet of air per minute. In order to get this excessive water gauge the fan has to run at fully 80 revolutions per minute, and as it was not thought wise to couple up the engines we had direct to the fan it was decided to drive the fan with grooved pulleys and cotton ropes, so proportioned that with the engines at 50 the fan runs at 80 revolutions per minute. The ropes are 15 in number, each two inches in diameter, and are amply strong enough to transmit 365 horse power per minute at 80 revolutions of driven pulley which is 9 feet 4 inches in diameter. The engines are in duplicate, horizontal, and condensing, having cylinder 30 inches diameter and 36-inch stroke.

This plant was erected to take the place of two underground furnaces, having a fire-bar area of 129 square feet, on which 12 tons 17 cwt. of Arley mine mixture were burnt

per 24 hours, producing with the furnaces very hard fired 142,570 cubic feet of air per minute, the cost for wages being 19s. 3d., and for fuel £4 3s. 7d., or a total cost of £5 2s. 10d. per 24 hours, which, multiplied by 365, will be £1,876 per annum.

When the fan was started it was found after careful testing that it got the same quantity of air as the furnaces when running at 52 revolutions per minute, burning 4 tons 2 cwt. of rough buzzard slack per 24 hours, and costing for wages, 10s. 6d.; and fuel, 15s. 4d.; or a total per day of £1 5s. 10d., which, multiplied by 365 gives a cost of £471 per annum, or a saving by the use of fan on the two items of fuel and labour of £1,405 per annum. Of course from this an allowance ought to be made for interest, depreciation, stores, &c.

In addition to this great saving, we were able to increase the quantity of air in the mine enormously, the fan producing at 80 revolutions per minute (at which speed it works quite easily and practically noiselessly) an increase of 56 per cent. in the quantity of air, namely, from 142,570 with the furnaces to 222,750 with the fan; the latter quantity being produced under a water gauge of 4·7 inches in the fan drift, and 4·95 inches at the fan side next to engines. The useful effect calculated on the lesser water gauge in fan drift being 70·3 per cent. of the steam power in cylinder of 234 horse power. This test was made soon after the fan started, at which time the upcast (230 yards deep) was unbricked, and nine feet in diameter for half its depth, and ten feet in diameter bricked for the remaining half, and in order to lessen the friction of air in the upcast it has since then been enlarged to 14 feet in diameter, and when this work was about half completed another test was made, and the fan was found to be giving 74 per cent. of useful effect, this result being obtained from

an average of 11 diagrams taken at certain intervals during the whole duration of measurements of air, which were taken with carefully tasted and corrected anemometers underground, on account of the difficulty of accurately measuring the air close to the fan.

This enlargement of the upcast will it is expected be finished in February, when the quantity of air produced will be much larger than now; and I may say that I should have preferred reading these notes after that had been completed, and another set of experiments had been made with the fan shutter adjusted to the altered conditions. However, I thought you would perhaps prefer seeing the place when the stripping was in progress, and so I obtained permission of the Wigan Coal and Iron Company for the members of this society to visit the colliery, hence my speaking on this occasion.

Of the electric light, which some of you saw in use in the shaft to-day, Mr. Webster, the manager, tells me that they could hardly have done without it, and although it has been an expensive matter to the company to buy the requisite plant, yet it has greatly lessened the risk to life and limb of the persons engaged on the work, and has also most decidedly saved loss of time and consequent loss of money. The lights in the shaft—3 in number of 50 candle power each—are Swan incandescent lamps; the engine and dynamo being powerful enough to give 10 lights of that power.

The enlargement of upcast has been carried on continuously since the commencement in the third week in August, and is now completed for 170 yards, and this work has necessitated no stoppage of work in the mines ventilated, and has been a very good test of the strength and capabilities of the fan. The bearings of the fan in the drift have been kept boxed in to keep them free from dirt and grit; and I am told that every Sunday, when the fan has

been stopped for examination, several barrow loads of grit and stone refuse have been cleared out of the fan race, which it has pulled up with the air current. Owing to the fear of the bearings heating with dirt, &c., getting in the fan has been kept at 70 revolutions per minute for the last four months, but it could just as well be driven at 80 or 100 if the bearings kept right.

In conclusion, let me briefly state what advantages I claim for the silent Guibal fan.

1st. That fans of this type, of from 12 to 20 feet in diameter, are able to do, at the same blade-tip speed, just as much work as any Guibal fan of the usual size of say from 30 to 50 feet in diameter.

2nd. That on account of their less size and weight they are not so liable to break down and injurious straining, and for the same reason are much more economical than the larger Guibal or any other type of fan, as if my fan is properly proportioned for the work it has to do there is no reason why it should not get 70 per cent. of useful effect as compared with the results of 40 per cent. up to 52·95 per cent. given in the report of the North of England committee.

3rd. They are less costly to erect on account of the less size of the fan and casing, and the requisite foundation and excavation, &c., than a Guibal would be to do the same work.

4th. They can be made as small and light as the Schiele, and will give equal water gauges and quantities of air at an average of two-thirds of the speed that would be required by a Schiele to do the same work. In brief, I claim for the "Silent Guibal" fan that is the cheapest, most efficient, and economical fan yet brought out, and I shall be glad to promise any person equally good results to those I have shown this afternoon; and as to cost, either I or my licensees, Messrs. Black, Hawthorne, and Co., of Gateshead-

on-Tyne, will be most happy to give any information on that score.

A vote of thanks to the Wigan Coal and Iron Company and their officials for their courtesy in allowing the Members to visit the Dairy Pit, for the purpose above-named, was passed.

Mr. HILTON said that the proprietors of the Colliery would be glad to give those members who desired to see the fan at work, and had not been able to attend that day, an opportunity of inspecting it at some future time. He had had a great deal to do with the experiments referred to by Mr. Cockson, and could endorse all that that gentleman had said as to the results. For some time prior to Mr. Cockson bringing out his fan, the Company had been on the look out for a better means of ventilating the colliery than they then had. The works were getting extensive and they were at the far end as regarded furnace ventilation. He went to South Wales and other places to see what was being done there, but did not find anything better than he could see about home. After some time, Mr. Cockson set to work and brought out the fan somewhat as you have seen it to-day. It gave every satisfaction, and did all that Mr. Cockson said it would do; in fact he did not know if it was not doing a little more. They knew before it was erected it would do what he said it would, for the reason that large models had been made and experimented upon. They naturally did not like to erect a fan on a new principle without first making experiments. Had Mr. Cockson not brought out this fan they would have put a larger one down. They thought of having one of 40 feet diameter, which would, of course, have cost more money. With such a fan, moreover, they could not have got an equal number of revolutions per minute. When a fan of that size got to about 50 revolu-

tions per minute it began to show signs of weakness, and he thought there would be difficulty in getting a 40 feet one of the old type to run more than 55 revolutions per minute.

Mr. G. H. PEACE considered Mr. Cockson had made a step in the right direction with the principle of his improvement on the Guibal fan.

Mr. MACALPINE remarked that the great merit of the Guibal fan was the high water gauge produced with a given periphery speed, and if the diameter of the Guibal fan could be reduced, and produce the results that Mr. Cockson had indicated, no doubt a very great step would have been made. The percentage of useful effect that was got out of the fan seemed to him to be remarkable. Some other fans had under very favourable conditions given as high a percentage of useful effect, according to the published reports, and therefore it would be very well if a series of exhaustive experiments were made on this particular fan. There was a large difference in the cost in fuel and wages between the fan and furnace system of ventilation, but probably before the subject was set aside Mr. Cockson would take into consideration what the difference would be after making allowance for interest on capital, depreciation, &c. The question of repairs was after all the main question, especially if one compared this fan with the Guibal fan. The Guibal fan, he understood, had always been a costly one for repairs. On the other hand, the Schiele and Waddell cost next to nothing for repairs. They ran on until they were done, without costing anything, and that, of course was a very important matter, for the repairs of the fan meant the stoppage of the colliery.

Mr. COCKSON said he quite agreed with Mr. Macalpine that a Schiele or Waddell fan might be preferable to the ordinary Guibal as regarded repairs. His paper was only intended to be a brief description of his fan. It was not

intended to be argumentative nor to compare his fan with others; but one of the things he claimed was that it possessed the advantages of the Guibal without any of the vibration. Hence it did away with that straining and that jarring which caused repairs to be necessary. He did not see why his fan should not run on for 20 or 30 years without a bolt straining or being out of repair. As to cost, the risk of fire underground when there was a furnace was something which could not be over-estimated. There were four pits in the vicinity of the Dairy Pit, which formerly were ventilated by furnaces, and in three of them he had known fires to arise from the furnaces within the past ten years. But apart from that risk he contended that the use of his fan entailed much less cost upon the proprietors of a colliery than any other system of ventilation did.

Mr. J. L. Hedley observed that the question was not so much one of furnace ventilation as compared with fan ventilation, as a comparison between different types of fan. The one they had seen to-day was an improvement on the Guibal fan, and at some future time they might expect, from what Mr. Cockson had said, to have the fan thoroughly tested by competent people and compared with other fans, and the results made known. At present the results obtained from the working of Mr Cockson's patent fan seemed to be very good indeed. He thought every one was agreed that the fan was preferable to the furnace, and as a matter of fact it was coming into general use where improved means of ventilation were required. He would like to suggest that they keep this question open for a short time, to give Mr. Cockson an opportunity of having his fan tested, when the enlargement of the upcast shaft has been completed to the size now in progress, in order that they might make a comparison under fair circumstances between it and the other fans that had been tested.

Mr. DAVENPORT (Oldham), pointed out that the fan was not working under such favourable conditions as it would do when the upcast shaft enlargement now going on was completed.

Mr. COCKSON intimated that he would be happy, with the Wigan Coal and Iron Co.'s consent, to have an official and authoritative test made of the fan so soon as the shaft was finished.

A vote of thanks was passed to the Chairman, and to Mr. Maskell Peace for the use of the Mining School, and the meeting terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XVII. SESSION 1883-84.

At the ORDINARY MEETING of the Members of the Society, was held on Tuesday, the 5th day of February, 1884, in the Literary and Philosophical Society's Rooms, George Street, Manchester.

EDWARD PILKINGTON, Esq., J.P., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for, and duly elected ordinary members of the Society :—

GEORGE GREEN, Tyldesley Colliery, Tyldesley.
JOHN JOBLING, Barcroft, Cliviger, near Burnley.
A. H. LEACH, Brinsop Hall Colliery, Wigan.
WILLIAM RODGERS, 48, Talbot Street, Southport.
DANIEL TOMAN, Chamber Colliery, Oldham.

FURTHER NOTES ON THE MARSAUT SAFETY LAMP.

By Joseph Dickinson, F.G.S.

In my Paper on the Marsaut Safety Lamp, read before this Society in November last, and now printed in the Transactions, I pointed out the advantages claimed for this lamp. It was at first my intention to wait for discussion, but events were hurried on by the want of a kind of lamp like this, forming a happy medium between the Davy and the Mueseler, in a colliery, where the Davy had apparently failed, and the Mueseler was objected to on account of the difficulty of keeping it lighted in such a thin seam.

Having only the statements, with such observations and experiments as were available without a proper testing apparatus, I could not take the responsibility of sanctioning the change unless fully satisfied of its security. I therefore lost no time in availing myself of the kindness of Mr. J. T. Green, of Celynen, to have the lamp tested in quick and varying currents of an explosive mixture. These tests, as shown in the account appended to my printed paper, proved that the lamp certainly went out in an explosive mixture, but also that after the lamp went out gas continued to burn inside the gauze. Various methods were tried, until it was found that, by closing the side inlets and lessening the size of the inlet and outlet apertures, the lamp became entirely self-extinguishing. In this modified form lamps have been made, and they are now being worked in the colliery alluded to, the result being, so far as it has yet come under my notice, that they suit the men in the working places, but, being more liable than the original Marsaut to go out when tilted, they are not liked for travelling with.

Having sent a copy of my Paper to Monsieur Marsaut, he has favoured me with his views, to the following effect:—

He says, that, at the commencement of his experiments, he thought the continuance of gas burning inside the gauze after the lamp had gone out was dangerous, or at least that it would be better if got rid of, and the idea of restricting the apertures in order to obtain complete extinction occurred to him; but, finding that he could not accomplish complete extinction without sacrificing essential qualities of the lamp, he concluded, before making such a sacrifice, that it should be shown that this continued burning of the gas inside the gauze constitutes any real danger. He considers that a relatively large quantity of air and gas is requisite to maintain the flame of the lamp and to cool the gauzes and other parts, and that the shield, under all circumstances, has the effect of placing the lamp as if it were in the midst of a quiescent inflammable mixture, in which situation, as one gauze suffices to disperse the heat, it is much more effectively done with two gauzes; and that, under such circumstances, the continued burning of the gas inside the gauze is nothing more than a presumed danger—a *feu follet*—or Will-o'th-Wisp; and that as, in experimenting with the lamp having the shield on, the Engineers of the French Commission, the Engineers of the Belgian Commission, and himself, were unable to make the flame pass out, it is desirable to retain the present arrangement, and that as yet the necessity of any alteration has not been demonstrated to him.

Such being M. Marsaut's view, I have again, through the kindness of Mr. Green, had further tests made, in order to ascertain for what length of time gas burning inside the gauze of the Marsaut is only a presumed danger, and if possible to explode the lamp; and the following are the results of 15 tests, without in any one instance passing the flame outside.

Nos. 1, 2, and 3, with the ordinary lateral explosive current in the testing box, continued respectively 11, 26, and 21 seconds. Others, with boards placed in the testing box so as to cause upward and downward currents—Nos. 4 and 5, continued respectively 7 and 6 minutes, the gas burning in the lamp until shut off from the apparatus. Nos. 6, 7, 8, 10, and 11, continued respectively 3, 4, 10, 11, and 7 minutes. No. 9 continued 40 seconds. No. 12, with oil on the inner gauze and copper rings, which evaporated by the heat and condensed near the inlet apertures, continued 1 hour and 22 minutes, when, apparently by a momentary irregularity in the current, the burning gas in the lamp went out—on this occasion when the lamp was removed from the testing apparatus the shield was found to be about 350 degrees Fahrenheit. Nos. 13 and 14 were continued respectively 22 and 40 seconds. No. 15 was continued 15 minutes.

The lamp, I may add, does not appear to be at all injured by the tests.

It may be a fair inference that as the shield attained a temperature of about 350 degrees Fahrenheit in 1 hour and 22 minutes, the heat would in time, if an experiment were continued long enough, become sufficient to pass the flame. The tests show, however, that great reliance may be placed upon the lamp; and as it gives more than double the light of the Davy, and does not go out easily when tilted, it seems likely to suit the requirements of many collieries. For those who object to a lamp in which gas continues to burn inside the gauze in an explosive current, there is the lamp in the modified form, with the smaller apertures. For those unaccustomed to test for gas with the lamp in full flame, there is still the Davy, which, with the tin can, may, under ordinary circumstances, be safely used by firemen for testing. But, with the Mueseler and the Marsaut to choose between,

there seems no longer any excuse for continuing to work with the Davy where it may become exposed to an explosive current.

The PRESIDENT said that the subject of safety lamps was one in which, at present, great interest was being taken; and the members must feel deeply indebted to a gentleman of Mr. Dickinson's authority for a paper of such interest and value.

Mr. TEALE, in criticising some of the points in Mr. Dickinson's former paper (read at the November meeting), observed that he should have felt some diffidence in speaking about the Marsaut lamp had not Mr. Dickinson mentioned the discovery that, under certain conditions, gas continued to burn underneath the gauze after the light had gone out. That being the case, it seemed to him the lamp could only be deemed safe within certain limitations. The burning of the gas must, if long continued, radiate sufficient heat to pass outside the gauze and ignite the surrounding atmosphere. In the modified lamp, of course much was done to correct this defect. But there was one difficulty with regard to it which he could not get over—and it was this. In the use of a safety lamp it was desirable to have the air as pure as possible. If you reduce the inlet and outlet apertures to a small size the lamp may, in the main roads, burn particularly well; but in places where the atmosphere is vitiated the light must be interfered with, because the products of combustion have not the power of escaping so readily as they ought. He would point out further, with reference to the results arrived at by M. Marsaut, they had no means of knowing what tests he had used. They had no information at all as to his methods. There were one or two passages in Mr. Dickinson's translation of M. Marsaut's paper to which he would

briefly refer. First, the covering up of the gauze—if it was to have a loose top—might degenerate into a system of having the top taken off, when the lamp got too hot, by the men in the pit; and that was a thing which ought to be prevented. On the other hand, if you have a shield permanently fixed you have another difficulty—you cannot examine the lamp effectively before allowing it to go down the pit. Then, the advantage claimed from the Marsaut lamp with regard to tilting would bring danger with it which it would be well to bear in mind—that was a danger arising out of the common practice of hanging the lamps on the side of the coal, out of the perpendicular—when, if the flame impinged against the glass, it might so overheat it as to fracture it. Some tests which he had carried out himself showed rather extraordinary results. The severest test to which a lamp could be subjected was a test with pure hydrogen gas: if it came through that satisfactorily it might reasonably be considered safe. He had seen lamps tested in this way—the Davy, Clanny, and Stephenson—the lamp being placed in a tin can with an aperture at the bottom connected with which was a flexible tube, the top being closed in with a piece of card board. The release of gas from the bag instantly caused an explosion so severe as to remove the top from the can. In Mr. Dickinson's paper (p. 187) it was stated with reference to the Marsaut:—"It does not fire in an explosive still mixture of air and lighting gas, as has been proved by upwards of 12,000 trials at Bessèges, when most of the other lamps did so, the Belgian Mueseler included." That, he thought, needed some explanation. The number of experiments was certainly large, namely, 12,000, and it would have been an easy matter to have stated the nature of the tests. On page 188 he found it stated:—"With three forms of the Marsaut lamp, testing two lamps of each

form, upwards of six thousand trials failed to produce a single external explosion, whereas fifteen Belgian Mueselers tested simultaneously, each of them about a hundred times over, let the flame pass* through the horizontal gauze diaphragm in 31 per cent. of the trials, and in 2½ per cent. produced explosion outside the lamp." Now, in whatever way this passage was read it was open to question, because if the horizontal gauze was so defective as to pass the flame outside in 31 per cent. of the tests there would have been external explosions not only in 2½ per cent., but in the whole 31 per cent. if the experiments had been continued. Then it was said :—"The trials also show that the Davy of small diameter, still used in England by the fire-trier, but abandoned in the Anzin and Bessèges collieries, *presents* important advantages, and if sufficiently protected against strong currents would possess a high degree of safety." Cork, if surrounded in the same way as the Marsaut lamp, would practically present the same results. M. Marsaut said, with regard to the mesh of the wire gauze, that the finer it was the safer the lamp would be, but he (Mr. Teale) failed to see this. His experience showed rather the contrary to be the fact. So long as you allow sufficient apertures for the admission of air to support combustion, then the stronger the wire is the longer the lamp will stand a certain test in an explosive mixture; whereas the finer the wire the more easily it is exploded. Coming next to the photometric tests of these lamps—here again was an entire absence of any explanation as to how the tests had been made, and certainly they were not calculated to give confidence in the results. The compara-

* Mr. Grimke, in vol. xvi., page 378, states :—"We put the Mueseler lamps into one of our mines, and they proved a failure, as I myself have seen them fire three or four times over. The only question with us was whether the flame of the gas went up the chimney or through the horizontal gauze."—Ed.

tive lighting power of various lamps tried by M. Marsaut was given—English standard sperm candles of six to the pound, burning 120 grains per hour being 100—and in the table the Belgian Mueseler was given as 49 compared with the English Mueseler 44. Now, as against this, he would quote the authority of Professor Wills. This gentleman tested most carefully the actual working of the lamp and the action of the air on the light with regard to its photometric value, and he showed unmistakably—and anyone who would take the trouble to make the test for himself would be thoroughly satisfied—that, taking the Clanny and the Mueseler both with the same class of glass and size of frame, exactly alike, there was a difference of something like 20 or 25 per cent. in favour of the Mueseler type of lamp. These were experiments which he (Mr. Teale) had himself frequently repeated; and in all cases he found that to be the case. It was easily explained, because in the Clanny lamp the air comes in at the top and reduces the light-giving power, whereas in the other it comes in from below, reaching first, in its passage, the coolest part of the flame. To keep the lamp in a condition of greatest safety it was necessary to get rid of the heated results of combustion as rapidly as possible. If they had a chimney inside the lamp, surrounded by flame, it would rapidly become red hot, and in that condition, without a shield, it was infinitely more dangerous than the Davy lamp, and would fire in a less space of time. Mr. Dickinson said that M. Marsaut's tests (referring to the Boty, Clanny, and Belgian Mueseler lamps) "point unmistakeably to the desirability of reducing to the utmost both the total internal volume of a safety lamp, and also the height of the glass, since the blind space enclosed by the glass acts like a cannon in propelling the inside explosion violently against the gauze, and so driving the flame out through it." He (Mr. Teale) challenged this. He would

not go the length of saying that he had made six thousand or twelve thousand tests, but he had made many hundreds of tests in all conditions of still explosive gases—hydrogen, coal gas, and pit gas—in every way and shape, and he had failed, with the Belgian Mueseler lamp ever to cause an explosion outside the lamp; and certainly he would like, if an opportunity presented itself, that M. Marsaut should explain by what process he effected the results described. It was, in his opinion, most important that they should know that. There were, at the present time, over 150,000 Mueseler lamps in use in the United Kingdom, and if the Mueseler would explode in an atmosphere of gas it was quite time that its use was put a stop to, as well as the Davy. Then in the matter of testing for gas it was stated that "the plan long in vogue at the Bessèges of ascertaining the presence of fire damp by measuring the elongation of the lamp's full flame is safer than reducing the flame to the utmost for the purpose of seeing the blue cap of gas better; the elongation of the flame is always a sufficient indication." His experience was, if it was desired to ascertain a small per centage of gas a small flame was decidedly the best to try it with. If it was carefully done the fireman would ascertain near enough for the purpose required; and he should think it would be a questionable practice to give instructions to those inspecting mines to use their lamps at full flame, because they would pass many places containing a per centage of gas which ought not to exist. He would simply, in conclusion, repeat that they ought to have from M. Marsaut some explanation of the method he adopted of testing these various lamps. In conversation with Mr. Dickinson, in regard to this matter, that gentleman made one remark which he thought was very pertinent. "There are," he said, "tests and tests;" and that might account for certain results which would hardly be borne out upon investigation.

Mr. MACALPINE said he had had some little experience of the Marsaut lamp at the Moorfield Colliery, near Accrington, and there were one or two points in connection with it upon which he might perhaps express an opinion. To begin with the light-giving power of the lamp, the question arose in his mind whether they were dealing with a lamp which, on account of its restricted area for inlet and outlet, was very much inferior to the Mueseler. He, therefore, constructed a simple photometer for the purpose of measuring the light-giving power of these lamps for himself. The measurements were easily readable within 2 per cent., and the result was as follows:—First of all, he took one of the Protector Mueselers and one of the Marsauts. The two lamps were precisely similar, with the exception that one had a Mueseler top, the other a Marsaut top. Out of five experiments, which he tried at different times, after the lamps had been trimmed separately—that was to say, one experiment after each trimming of the two lamps—out of these five experiments he could not get a variation of more than 4 per cent. in the light-giving power of the lamp. Twice it was in favour of the Mueseler, twice in favour of the Marsaut, and once they indicated alike. The result of the experiments was this, that the average of the tests was in each case 100—that was to say, the Mueseler and the Marsaut were equal. With regard to the test for light, he might remark that it was extremely difficult to test, as was usually done, to the sperm candle. Two sperm candles, which appear perfectly alike, will give in burning a very great difference in total effect—a difference of something like 11 per cent., whilst the variation at at any one moment may be as high as 37 per cent., so that there is an enormous margin for error. But, on the other hand, if two lamps were compared the result might be very different. Mr. Teale's lamp had the merit of burning with

very great steadiness, and for an hour together there would be very little variation in the amount of light given. After these experiments he proceeded to test the Marsaut and the Mueseler burning with oil. The lamps again were of exactly the same pattern, with the exception of the tops; the areas were very much the same, and the result was precisely similar. There was very little variation indeed in the light-giving power of the lamps—not more than one or two per cent. When, however, the shield was put on the Mueseler—and there are many who do not consider the Mueseler safe without the shield—the amount of light which was given with the oil Mueseler, with the shield, was 81 per cent. as compared with the Protector lamp, against 87 per cent. given with the Mueseler without the shield.* On the other hand, bringing the Marsaut lamp into something like the condition of M. Marsaut's lamp, so far as the

* Comparison of Mueseler and Marsaut Safety Lamps.

	Weight Trimmed.		Areas.			Height of Flame.	Comparative Lighting Power.	
			Inlet.	Outlet.	Chim'ey		Mueseler burning spirit—100	Sperm Candle burning 120 gr. per hr.—100.
	lbs.	oz.	Square Millims.	Square Millims.	Square Millims.	Milli-metres.		
Mueseler burning spirit..	3	2	..	..	87	29	100	
Marsaut ,, .. (Area of inlet and outlet contracted, as suggested by Mr. Dickinson.)	3	6	540	330	..	29	100	
Mueseler burning oil	3	0½	..	..	78	21	87	
Ditto with shield	3	4	224	large.	78	21	81	
Marsaut burning oil .... (Area of inlet and outlet contracted, as suggested by Mr. Dickinson.)	3	5	252	385	..	21	87	
Marsaut burning oil, with shield removed..... (Will probably compare better for lighting power with Marsaut's own lamp.)	..		..	..	..	21	102	55 to 60
Davy burning oil	2	5	..	..	..	21	32	

Note.—The bottoms, glasses, and frames of the lamps bracketed together were of exactly the same pattern.

amount of air was concerned, and raising the can from the Marsaut lamp, the oil lamp gave 2 per cent. more light than the Protector. The result of these experiments was thoroughly to satisfy him on this point—that we have in the Marsaut, with the restricted openings, as modified by Mr. Dickinson, a lamp that will give an equal light in the mine to the Mueseler, and he did not think that that condition of affairs would be altered in the mine, because he did not believe that there would be any more restriction of the air reaching the flame in the Marsaut than there was in the Mueseler. So much with regard to the light-giving power of the lamp. Now with regard to its *handiness*. His firm worked a very low mine (often not more than 2ft. 6in.), in which it would, of course, be almost impossible to work with the Mueseler. With the Marsaut, which has been introduced since the explosion in November last, they found no difficulty so far as the men were concerned; they liked the lamp, and after the first day or two no inconvenience was felt in its use. The men were at first a little bothered in getting to their places, but that was the only inconvenience they experienced. On the other hand, the drawers had, and still have, considerable difficulty. What with the tenderness of the lamp, owing to the use of spirit, and its tenderness so far as tipping was concerned, they had not got on very well with it. He quite expected, however, when they introduced the oil lamp, as was proposed, for the drawers these difficulties would cease. He found that the oil lamp was not a particularly tender lamp, in the Marsaut form, even with the restricted areas. It would be almost impertinent for him to speak as to the safety of the lamp. To him Mr. Dickinson's experiments seemed very satisfactory; and the tone of M. Marsaut's paper, and the extracts which Mr. Dickinson had furnished, had a somewhat different effect upon his mind from what it seemed to

have on Mr. Teale's—possibly because he (Mr. Macalpine) had not had as much experience as that gentleman. At any rate it seemed to him to be a very carefully-written paper, and one on which they might rely. He did not see why the conditions under which gas burned in the Marsaut should not be comparatively safe if they took into consideration the fact that there were very small inlets, that a very limited quantity of the explosive mixture goes into the lamp, and that there was a large area of gauze to disperse the heat. The conditions were altogether different from those in the Mueseler. He must express his own indebtedness to Mr. Dickinson. If he had not come forward with the Marsaut lamp when he did, he (Mr. Macalpine) did not know what they would have done. It had in the Altham mine taken the place of the Davy, and taken it well.

Mr. DICKINSON said he had condensed M. Marsaut's statements very considerably. M. Marsaut went into the subject very minutely, his observations occupying eight pages of large quarto paper, but he had given the meeting all the essential points.

ON THE PIELER LAMP FOR INDICATING SMALL QUANTITIES OF FIRE-DAMP.

By C. Le Neve Foster, B.A., D.Sc., F.G.S.

The object of my paper is to call attention to some simple methods of testing the air of mines, which are described in a pamphlet* written last year by Herr Pieler, a German mining engineer, formerly in the Prussian Government service, and now manager of some collieries at Dortmund.

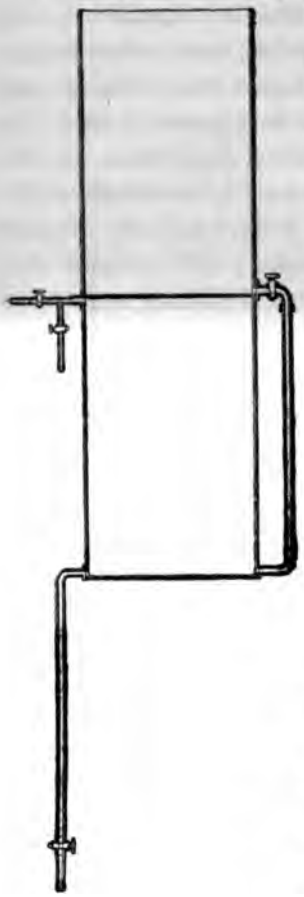


Fig. 1.

Herr Pieler considers that the percentages of fire-damp and carbonic acid in the atmosphere of collieries should be determined daily and carefully recorded and tabulated. The plan he adopted at the Gouley Colliery, near Aix-la-Chapelle, consisted in ascertaining the quantity of fire-damp by experiments carried on both above ground and underground.

At some convenient place on the surface he set up a cylindrical aspirator (Fig. 1†) holding 15 gallons (70 litres), and, placing it in communication with the upcast shaft by a pipe, he caused

* "Ueber einfache Methoden zur Untersuchung der Grubenwetter," by Fr. Pieler; published by Rudolph Barth, Aix-la-Chapelle, 1883. pp. 19 with 5 woodcuts, price one shilling.

† The blocks for the illustrations have been kindly lent by the publisher, at Herr Pieler's request.

it gradually to become filled with the air of the mine by allowing the water contained in it to run out slowly. The open top of the aspirator was then filled with water, and by properly turning the cocks the sample of air was forced out gradually; it was tested for fire-damp by observing the effect it produced upon a burning jet of hydrogen when allowed to issue all round the flame. Fig. 2 shows the hydrogen generator, and Fig. 3 the

Fig. 2.

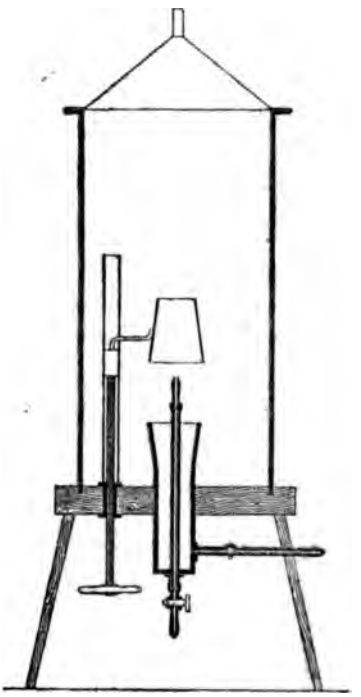


Fig. 3.

burner, surrounded by a pipe supplied with air from the aspirator. MM. Mallard and Le Châtelier, of the French Fire-damp Commission, have pointed out the value of the hydrogen flame as a fire-damp indicator, but for making

experiments underground there are difficulties in getting a convenient portable hydrogen lamp.

Herr Pieler finds that $\frac{1}{4}$ per cent. of fire-damp gives a "cap" or aureola $\frac{4}{5}$ inch (20 mm. high), which increases considerably in height and also in intensity of colour as the proportion of fire-damp rises. With practice any proportion between $\frac{1}{4}$ and 3 per cent. can be estimated within a quarter of a per cent.

Fig. 4.

Knowing the size of the upcast shaft and the velocity of the current, and having made a determination of the percentage of fire-damp by means of the hydrogen flame, it is easy to calculate the total quantity of fire-damp issuing from the mine every day.

For use underground Herr Pieler's spirit-lamp is more convenient than a hydrogen lamp, and according to his experiments it affords sharper indications of small quantities of fire-damp. I will now give a translation of Herr Pieler's description of it:—

"The spirit-lamp, which serves "for the examination in the mine, "is a suitably altered Davy lamp "(Fig. 4). In order to produce a "clean and regular flame, it is necessary to prevent any "vapour of the spirit from acting on it. The wick is "therefore carried closely in a long neck, and all the "joints are made to shut tightly. The flame is regulated

"by means of a screw, which passes through a simple "stuffing-box at the bottom of the spirit-holder. It is "advisable to make the latter rather larger than in an oil- "lamp, so as to be able to carry a sufficient amount of spirit "for a journey through the workings. The wire gauze "must be made somewhat higher than usual in order to "admit of the full development of the 'cap' or aureola. "A small converging chimney is fixed above the burner; it "hides the flame for a height of 1½ inch (30 mm.), and "furnishes a fixed starting point for estimating the height "of the cap. The best spirit to use is absolute alcohol.

"The method of testing air with the spirit-lamp is pre- "cisely the same as with the ordinary Davy lamp. It is "advisable beforehand to regulate the flame in pure air, so "that the point of it is on a level with the top of the "chimney.

"According to the experiments made hitherto, the cap "which shows itself in air mixed with small quantities of "fire-damp behaves as follows:—With ¼ per cent. of fire- "damp it is slightly luminous, of a bluish-grey colour, fading "away on the outside, and about 1½ inch (30 mm.) high.

"With ½ per cent. it is 2 inches to 2⅓ inches (50 mm. to "60 mm.) high, more sharply defined at its lower end, but "still fading away above.

"With ¾ per cent. the blue colour appears more plainly; "the edges are sharper and the length of the conical cap is "about 3 inches (75 mm.)

"With 1 per cent. the cone is 3½ inches (90 mm.) high, "sharply defined and of an intense blue colour. With a "larger percentage the cap increases still further in height, "with 1¼ per cent. it is 4 inches (100 mm.) high, with 1½ "per cent. 4¾ inches (120 mm.), and with 1¾ it reaches the "top of the lamp. The luminosity increases in proportion "and the colour becomes deep blue.

"With 2 per cent. the top of the cap widens out "decidedly, and with higher percentages it continues to "expand until the inside of the gauze is filled with it. In "mixtures containing as much fire-damp as these, the Davy "oil-lamp exhibits a cap if the wick is drawn down till the "luminous part all but vanishes."

For determining the proportion of carbonic acid gas, Herr Pieler employs a specially constructed Winkler burette (Fig. 5), terminating in a long graduated narrow stem, which

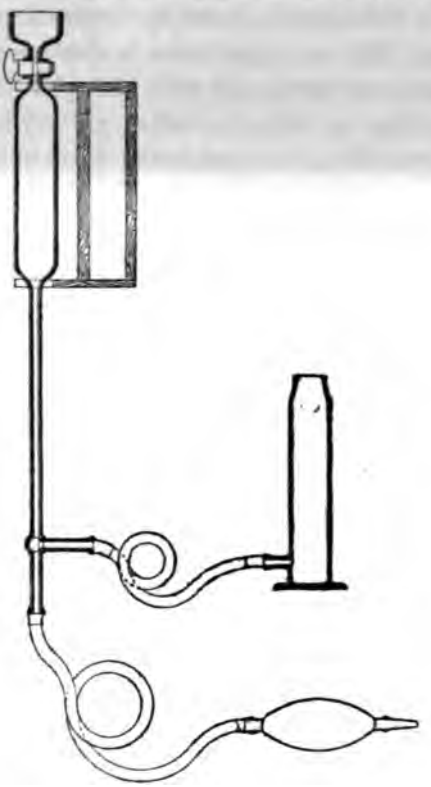


Fig. 5.

enables single thousandths of the contents (50 cubic centimetres) to be read off with ease. The carbonic acid is

absorbed by a solution of potash, and the reduction in volume shows the amount of the gas originally present.

Herr Pieler concludes his pamphlet by a copy of the monthly table kept at Gouley mine, which gives details concerning the quantity of coal raised, men and horses employed, working places, area of workings ventilated, length of air-ways, total quantity of air passed through the workings, quantity per man and per ton of coal, total amount of fire-damp evolved in 24 hours, amount per 1,000 square metres of area of coal seam, amount per ton of coal raised, percentage of carbonic acid gas, and amount of carbonic acid gas evolved by the coal in 24 hours.

The amount of fire-damp evolved per ton of coal raised in November, 1882, varied from 111 to 949 cubic feet (3·15 to 26·88 cubic metres) in different parts of the workings.

We now come to the practical question: "Is it necessary "or important to have better means of determining the "presence of fire-damp than by the ordinary safety-lamp?" I think there is no doubt that this question should be answered in the affirmative. According to competent observers it is practically impossible to detect the presence of fire-damp with an ordinary oil safety-lamp when the proportion falls below 2 per cent.* The experiments of Mr. Galloway, which have been confirmed and extended by Sir Frederick Abel, show that if a colliery is dusty the air may be rendered explosive by less than 2 per cent. of fire-damp; in other words the atmosphere may be dangerous to the miner without his being able to ascertain the fact.† Under these circumstances it is surely of great importance to

* W. Galloway, "On the Fire-damp Cap," *Proc. South Wales Institute of Engineers*, vol. x., page 290, and F. A. Abel, "Report on the results of experiments made with some of the dust at Seaham," *Reports of H.M. Inspectors of Mines for 1880*, p. 439.

† F. A. Abel, *Ibidem*, and *Preliminary Report of Her Majesty's Commissioners appointed to enquire into Accidents in Mines, 1881.* pp. xi. and 444.

obtain an instrument which will discover the presence of the dangerous invisible enemy, even when existing in very small proportions. In my opinion the Pieler lamp seems likely to render useful services in this direction. It is very simple and portable, and as its indications resemble, save in degree, those of an ordinary safety-lamp, any intelligent man would soon learn how to use it effectually. There is the disadvantage, however, that as it gives very little light he must carry an ordinary lamp to illuminate his path. I think it is necessary also to guard the spirit-lamp from violent jerks, for a sharp shake will eject a little spirit, which makes a large flame inside the gauze. This might be dangerous in a strong current. In order to obviate this risk, the reservoir might be filled with sponge; but I may remark that the spirit-lamp would always be in the hands of a special person, and would therefore be less likely to meet with rough usage than the lamp of an ordinary collier.

I find that my friends Professors Kreischer and Winkler, of Freiberg, in a report lately made to the Commission for revising mining regulations in Saxony,* fully confirm Herr Pieler's statements concerning the sensitiveness of his lamp to fire-damp. Their words are: "This lamp begins to "indicate with about $\frac{1}{4}$ per cent. of fire-damp; with $\frac{1}{2}$ per "cent. it shows a clearly recognisable aureola, which "deepens in colour with $\frac{3}{4}$ per cent., and with 1 per cent. is "nearly 4 inches (1 decimetre) long."

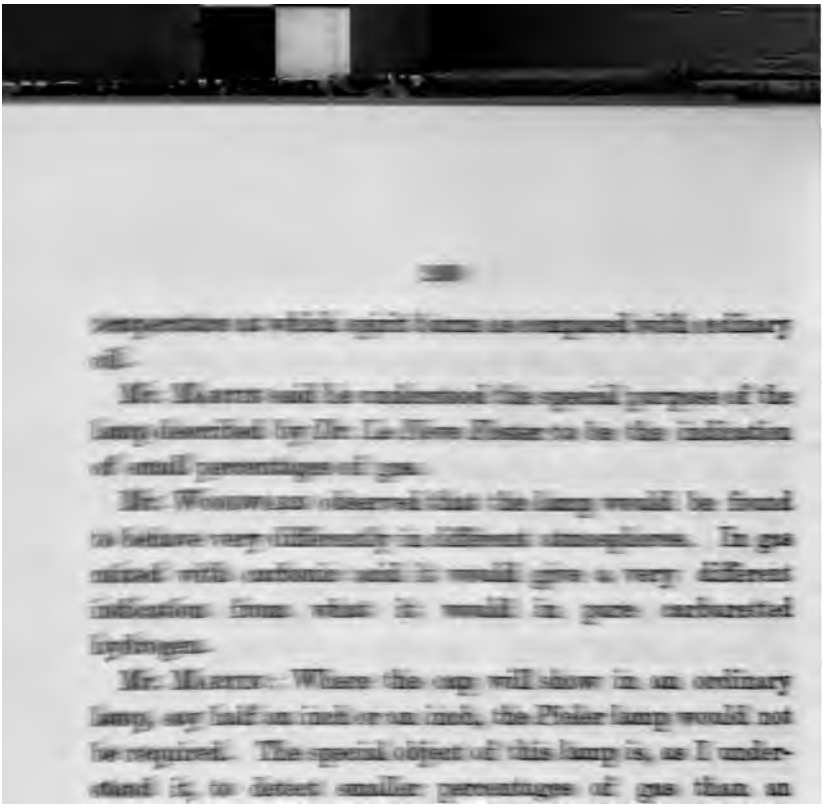
In writing to me a few weeks ago, Herr Pieler informed me that the spirit-lamp is being regularly used at numerous collieries in Westphalia and everywhere with good results.

**Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen auf das Jahr, 1884*, p. 77.

Mr. Woodward said he would like to know if the trials had been made actually in the mine, because the indications would vary considerably, according to the quality of the gas—whether it was mixed with a large percentage of carbonic acid—in which case the effects would be different from what they would be in the case of pure carburetted hydrogen.

Mr. Dickinson said Mr. Woodward's question was a very important one. He thought it was Mr. Teale, in his remarks on the preceding papers, who referred to elongated caps. Now, everyone who had had much experience of fire-damp knew perfectly that you do not get a cap of two or three inches in length unless the gas is mixed with some impurity, such as black damp, or the human breath, or the products of combustion. You have to judge by the intensity of the colour as well as by the length of the cap. There were many lamps now in use in which spirit was used; and in ordinary circumstances they would see a very much larger cap with the Protector lamp than with the oil lamp; in fact, if you look at the Protector lamp at times even when there is no gas, you may see a slight cap upon it; but what was wanted was to have a certain indicator, and not a lamp which would indicate one thing in one pit and another thing in another, or one thing in one part of a pit and another thing in another part of the same pit.

Mr. Woodward said another question arose, namely, as to how the lamp would behave in gas in which you get no cap at all—where it fires suddenly. In certain mines in Lancashire the gas is known to fire without presenting any cap in the lamp. He quite agreed with Mr. Dickinson's observations on the use of spirit; he had himself seen the same thing, and had been even in doubt whether there was a cap on the lamp or not. It was impossible to tell, and he doubted whether this was not owing to the very high



ordinary lamp would show, and from the experiments which have been made, it would probably be especially useful where shot-firing is carried on.

Mr. TEALE said it appeared to him that the lamp described by Dr. Le Neve Foster was a very interesting arrangement for detecting small percentages of gas, and he thought it was the only lamp by which such small percentages could be ascertained. He could quite understand the working of the lamp, and looked upon it as extremely reliable, because the temperature maintained was so high that it must at once reveal the presence of hydrogen, and show the cap fairly. He believed the smallest proportion of gas discoverable by means of an ordinary lamp was one in sixty. The Protector lamp would be found to exhibit a smaller percentage of gas than an oil lamp, because of the higher temperature of the flame.

Mr. HENRY HALL said he understood that the spirit used in the *Protector* lamp, and in the lamp described by Dr. Le Neve *Foster*, produced a flame of much higher temperature than oil. Might not this be a source of danger? Suppose any

of the spirit, through the jerking about of the lamp in the pit, was thrown upon the gauze of the lamp, oil under those circumstances would not burn, but the spirit would burn with such intense heat as possibly to light the gas outside.

Mr. TEALE said the effect produced would not be such as Mr. Hall supposed. In a lighted lamp the gauze became so heated that any spirit falling upon it would not adhere, and consequently would not ignite. There was, therefore, no possibility of the flame being carried through.

Mr. MACALPINE observed that, shortly after he introduced the Protector lamp, he was in an air-way with his manager, and screwed down the lamp very low, when he was surprised to find gas indicated.* This was in a fresh-air way. There was a distinct cap on the lamp. On testing with a Davy, however, he could find none, and he could well believe that there was none, because they were not many yards away from the shaft. Mr. Dickinson was in his office a few days afterwards when he had one of those Protector lamps lighted: he screwed it down again and put it under the desk, out of the day light, aud again even there, gas was indicated. When you go into a dark room and turn an ordinary gas jet low enough, you will find there is gas indicated there too. Encircling the blue flame on the burner and the small speck of white flame above it, a blue flame is distinctly seen of a deeper shade than the former.

Dr. LE NEVE FOSTER, replying to the questions and observations of various speakers, said—first, as to whether this lamp had been tried in the mine with gas: he knew Herr Pieler had tried it continuously in mines, and it was being largely used in mines at the present time for the pur-

* Mr. J. S. Burrows says, vol. xvi., page 368, that mineral oil shows a blue cap without the presence of gas. Mr. Unsworth confirmed the statement.

If the lamp is not constructed so as to prevent any vapour escaping out of the mineral oil reservoir from coming in contact with the flame, the fact is readily explained.—ED.

pose of detecting small quantities of fire-damp. He stated in his paper that it was in practical use abroad for that purpose. Another point was whether the presence of carbonic acid gas would affect the indications of the lamp. So far as he could judge from Herr Pieler's pamphlet he should say that the amounts of carbonic acid gas ordinarily occurring in mines would not appreciably affect the result, and Herr Pieler mentioned cases where the amount of carbonic acid gas approached one per cent. Furthermore, in a report upon safety lamps lately made to the Saxon Government* by the Professor of Mining at Freiberg and the Professor of Chemistry, it was stated, as the result of numerous experiments, that even when the carbonic acid gas amounted to five per cent. the indications of ordinary safety lamps were not decidedly altered. He wished also to correct a misapprehension with regard to the word "spirit." Of course there were different kinds of spirit. It had been assumed by one of the speakers that the spirit which was used in the Pieler lamp was the same as that used in the Protector. Such, however, was not the case. In the one case it was alcohol that was used; in the other it was a mineral oil. In the Pieler lamp it was spirits of wine—alcohol—or, if desired, any one might use in place of that the cheaper commercial methylated spirit. The question had also been asked—how would the lamp behave in an atmosphere where there was no gas? He felt convinced that it would show fire-damp in a large number of mines where fire-damp was not supposed to exist; another question was asked by one gentleman, whether it would show a cap of fire-damp in cases where the gas with an ordinary Davy lamp exploded suddenly without any previous warning by a "cap."

* "Untersuchungen über Sicherheitslampen," G. Kreischer and Cl. Winkler, *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen auf das Jahr* 1884, pp. 11 and 76.

To that question he could give no answer; but he should be very happy to lend the lamp to any gentleman who might wish to make this experiment for himself. He might mention that he had had the lamp in his possession only about a fortnight. He had tried experiments at home with ordinary gas, placing an ordinary safety lamp and the Pieler lamp side by side, in precisely the same atmosphere of mixed ordinary gas and air. In mixtures which showed no cap whatever in the ordinary Davy lamp when drawn down quite low, he got a very decided cap—indeed a very long cap—with the Pieler lamp. Mr. Hall had remarked upon what he thought might be a possible danger from spirit escaping if the lamp had a very violent jerk. He (Dr. Le Neve Foster) had already alluded to this in his paper; he found, if he gave the lamp a sharp jerk, a little spirit came out and burned on the inside of the gauze; and it occurred to him that in order to prevent the possibility of an accident of that kind—supposing that there was danger from it—the reservoir might be filled with cotton wool, or with sponge, in order to prevent any loose spirit being jerked about. At the same time he thought it was fair to the inventor to remark that the amount of spirit that could be jerked out in that way was small and was very rapidly consumed; and in no case did he see the gauze get very much heated. It required a very considerable jerk to get any of the spirit out at all. On the other hand, if the lamp is very much inclined for a time, a little spirit may run out and burn; and it was with these facts in his mind that he proposed that cotton wool should be inserted in the reservoir.

In answer to a question by Mr. Teale, as to the rate of consumption of ordinary methylated spirit.

Dr. Le Neve Foster said he could give no precise information on that point, but he had had the lamp partly

filled, and burning for several hours without the spirit being consumed. The flame was comparatively small, the wick having to be screwed down until it was almost flush with the top of the wick-holder. In that respect it was not like an ordinary spirit lamp, where the wick projected a good deal.

Mr. DICKINSON: Mr. Teale may perhaps tell us whether he does not in all the Protector lamps use the sponge, and pour off all the spirit except what the sponge holds.

Mr. TEALE said that that was so.

Dr. LE NEVE FOSTER remarked that a lamp such as the Pieler would not be entrusted to an ordinary collier. Only one such lamp probably would be in use at a pit, or at one part of a pit, and a trusty person would go down occasionally, or daily if necessary, and make observations with it. There would, therefore, be little danger of any spilling of spirit, although no doubt it was desirable to provide against such a contingency.

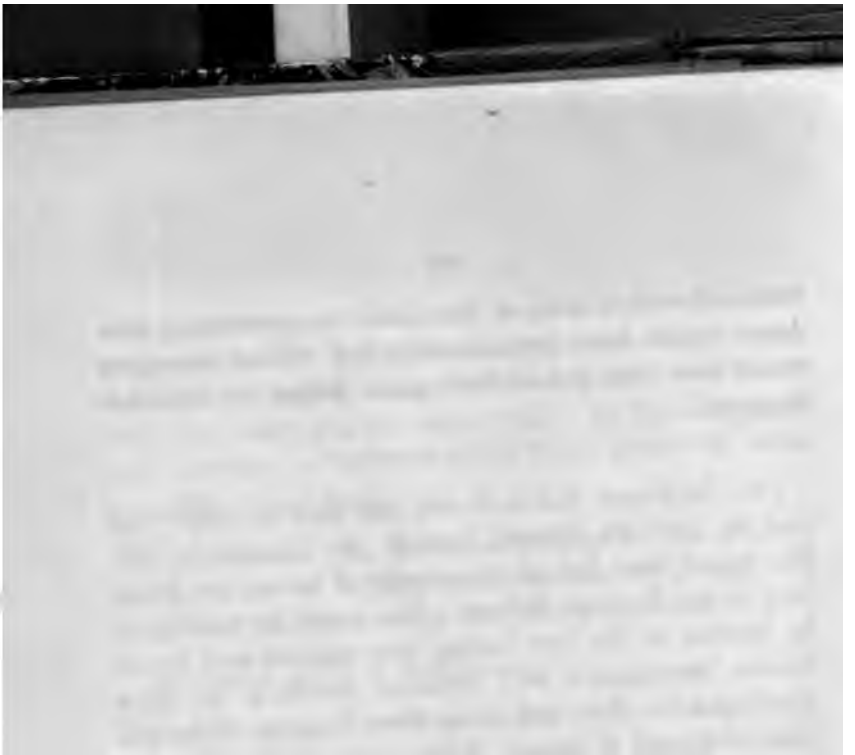
Mr. DICKINSON: Clearly the special use of that lamp in a colliery would be as a testing lamp, to be placed in the hands of the fireman.

The PRESIDENT said he would have to carry another lamp with him for lighting purposes.

Dr. LE NEVE FOSTER: This is a lamp that would be useful for the examination of places where gas is not known to exist, or of collieries which are considered to be perfectly free from gas, to see whether there may not be gas present. One hears at times of explosions in mines which had previously been considered free from gas, and worked with naked lights. It is possible, if these mines had been

examined with a lamp of this kind, the presence of fire-damp would have been detected, and colliery managers would have been put on their guard before the explosion happened.

[Mr. Dickinson desires to add that since the paper was read he and Mr. Martin, through the kindness of Mr. Woodward, have had an opportunity of testing the Pieler lamp in the Newtown Colliery. The screen for sending air by brattice to the face having been removed until the air became impregnated with sufficient fire-damp to show nearly quarter of an inch in the Davy lamp, the Pieler was then tried, and it showed about two inches of cap—thus proving the very great superiority of the Pieler for testing purposes. The tests were repeated with the Davy following the Pieler, with the same result.—ED.]



TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XVII. SESSION 1883-4.

At the ORDINARY MEETING of the Members of the Society, held on Friday, the 7th day of March, 1884, in the Mining School, Wigan;

WALTER TOPPING, Esq., in the Chair.

The following are the recent additions to the Library:—

Cornwall: Royal Geological Society of—Transactions, Vol. X., Part 6; *From the Society.* Cornwall: Royal Institute of—Journal, Vol. VIII., Part 1; *From the Institute.* Geological Magazine: January, February, March, April (Nos. 235—237); *Purchased.* Leicester Literary and Philosophical Society: Transactions for Years 1870-79; *From the Society.* London: Geologists' Association—Proceedings, Vol. VIII., Part 4; and Annual Report for 1883; *From the Association.* London: Geological Society—Quarterly Journal, No. 157, Vol. XL., Part 1; *From the Society.* London: Institute of Mechanical Engineers—Proceedings, No. 4, November, 1883, and No. 1, January, 1884; *From the Institute.* London: Iron and Steel Institute—Journal, No. 2, 1883, and Catalogue of the Library; *From the Institute.* London: Royal Institution—Proceedings, No. 76, Vol. X., Part 2. *From the Institution.* London: Royal Society—Proceedings, Nos. 227-229, Vols. XXXV. and XXXVI.; *From the Society.* London Society for Psychical Research: Vol. I., Part 4; *From the Society.* Mining Institute of Scotland: Transactions, Vol. V., part 7; *From the Institute.* North of England Institute of Engineers: Transactions, Vol.

XXXIII., Parts 2 and 3; *From the Institute.* Oxford University: Catalogue of Books added to the Radcliffe Library in 1883. Peacock, R. A., C.E., F.G.S.: Saturated Steam as the Motive Power in Volcanoes and Earthquakes; *From the Author.* Science Monthly: Illustrated Journal, Vol. I., Parts 1–6; *From the Editor.* Scientific Students' Association: Report and Proceedings for 1883; *From the Association.* South Wales Institute of Engineers: Vol. XIII., No. 6; *From the Institute.* Stirrup, Mark: Pamphlet on the Antiquity of Man in Great Britain, read before the French Association for Advancement of Sciences, in Reims, 1880; *From the Author.* Yorkshire Geological and Polytechnic Society: New Series, Vol. VIII., Part 2; *From the Society.* Dundee Free Library: Annual Report for 1883; Liverpool Free Library: Annual Report for 1883. Museum of Comparative Zoölogy, Cambridge, U.S.A.: Annual Report of the Curator, 1882-3; Bulletin, Vol. XI., Nos. 3 and 4; *From Alexander Agassiz.* American Institute of Mining Engineers: Vol. XI.; *From the Institute.* Geological and Natural History Survey of Canada: Report of Progress, 1880–81–82, with maps; *From Alfred R. C. Selwyn, F.R.S.* Montreal Natural History Society: The Canadian Record, Vol. I., No. I.; *From the Society.* Melbourne: Observations on New Vegetable Fossils of the Auriferous Drifts, by Baron F. von Mueller, Government Geologist of Victoria; *From the Department of Mines and Water Supply.* Melbourne: Reports of the Mining Surveyors and Registrars, Victoria, Quarter ending 30th September, 1883; *From the Department of Mines and Water Supply.* Académie Impériale des Sciences de St. Pétersbourg: Mémoires VII.e Serie, Tome XXXI., Nos. 5–9; Bulletin, Tome XXVIII., Nos. 3 and 4; and No. 1, Tome XXIX.; *From the Academy.* R. Accademei dei Lincei: Transunti, Vol. VII., Fasc° 16ed ult.; Vol. VIII., Fasc° 1–6; *From the Academy.* Società Toscana di Scienze Naturali, Pisa: Processi Verbali, Vol. IV., Parts 1 and 2; *From the Society.* Société Geologique du Nord, Lille: Annales, Tome X., 1882-83; *From the Society.* Société Malacologique de Belgique: Annales, Tome XVII. (3d Serie, Tome II., 1882), Tome XIII. (2d Serie, Tome III., 1878); Sundry Parts of Proces Verbal for Years 1880–1883; *From the Society.* Société Vaudoise des Sciences Naturelles, Lausanne; Bulletin 2e Serie, Vol. XIX. (No. 89): *From the Society.* Verein für Erdkunde: Halle a/s, Mittheilungen, für 1883; *From the Society.* Revue de la Législation des Mines, par Emile Delecroix: Mars, 1884, Part 1; *Presented by the Author. Subsequent Parts Subscribed for.*

WHAT WILL THE ROYAL COMMISSION REPORT AS TO LIGHTING AND BLASTING IN MINES?

By Henry Hall, H.M.'s Inspector of Mines.

During the four years that Her Majesty's Commissioners appointed to inquire into accidents in mines have been sitting, there has naturally been a disinclination on the part of those responsible for the security of mines to introduce any radical change in the precautionary measures usually adopted, because it has been felt that any recommendations the Commissioners might eventually make would carry great weight even to the extent of special legislation to enforce the more pressing and important, and thus expenditure might have been made for an object, at the time apparently desirable, but which the completed inquiry of the Commissioners might prove to be undesirable.

But although from this cause the practical application of additional precautionary measures may to a great extent have been in abeyance, yet it can by no means be held that the experience of the last four years of mining has taught no important lessons. In these days of scientific knowledge and applied science it would be impossible for such to be the case; indeed, as a matter of fact, perhaps in no previous similar period in the history of mining has so much thought and experiment been bestowed to gain a thorough knowledge of the various phenomena that present themselves, and so satisfactorily to guard against such as threaten the security of the workpeople, and all those whose daily avocation takes them underground.

It is not the writer's intention to detail at length the various matters to which this experience seems to point as needing careful consideration and readjustment, but simply

to say a few words on two of the most important, and which, by sheer force of circumstances, have been brought prominently to the front, viz., the *lighting of mines and blasting operations;* and here, to prevent any misconception, it must be distinctly stated that the writer has no means of acquiring information or knowledge of the individual views held by any of the members of the Royal Commission, which are not open to any of the members of this Society.

Lighting of Mines.

Now, what has the experience of the last four years taught us with respect to the *lighting of mines?* It has established beyond the possibility of contradiction that *any unprotected gauze* lamp such as the "Davy," the "Clanny," or the "Stephenson" is unsafe in the presence of an explosive atmosphere moving at even a moderate velocity; and of these lamps our old friend the "Davy" has come into the worst repute of all. The time has passed for us to be able to hug our old friends any longer, and the cause of this is quite clear. Some of you may think it is very old news, but you must remember that any discovery is of very little value until the lesson it teaches is acted upon.

We know the safety of the ordinary gauze lamp depends upon the fact, that the metal forming the gauze has the power, in a comparatively still atmosphere, of abstracting heat so rapidly that any body of flame, such as burning firedamp existing inside the lamp, is so reduced in temperature in its passage through the gauze that it no longer exists as flame, and consequently is incapable of igniting the explosive atmosphere surrounding the outside of the lamp. But, as has been mentioned, recent experience has proved that this is only true in the absence of any rapid movement of the explosive atmosphere, if by means of a draught or current of sufficient force (6 feet per second) the

combustion of the firedamp inside the lamp proceeds at such a rapid rate that more heat is given off than the abstracting power of the gauze can deal with, then the gauze rapidly becomes red hot and attains the same temperature as the flame itself, and the surrounding atmosphere is at once ignited. This is the usual character of the phenomenon, but it is also possible that in an exceedingly rapid explosive current the suck of the wind passing a lamp may be sufficient to lick the flame through the gauze before it gets red hot, in the same way as the mechanical effect of a pistol shot does, when fired in the vicinity of a lamp burning in a still explosive atmosphere, by setting up a vibration or wave in the air, and thus cause ignition to take place outside the lamp, as proved by Mr. Galloway several years ago.

The writer has tried to explain this matter of the passage of the flame through the lamp gauze because, although it is now quite familiar to most of us, yet we still hear mining people speak of lamps *bursting*, whereas the lamp is usually as intact and sound after the experiment as before, and the writer believes it is an error to suppose that a *white heat* is necessary to ignite firedamp, because a few weeks ago, whilst experimenting as to the power of sparks from a pick or other tool to light gas, it was found quite easy to ignite a blower of firedamp with a red hot poker after it had been carried twenty yards in the open air.

In several recent disastrous explosions the evidence given at the inquests has pointed strongly to the failure of the lamps in use to withstand a rapid current of explosive gas. In speaking of the Risca explosion. where 120 lives were lost, Mr. R. S. Wright, the gentleman selected by the Secretary of State to represent the public in conjunction with the inspector of the district, says in his official report, "The 'Clanny' lamp, however safe it may be in a slow

"current of ventilation, is not reasonably safe, and its use "should be prohibited, where the velocity of the air current "is so strong as at Risca. Its use under the conditions to "the existence of which the evidence points is sufficient to "account for the firing of the gas emitted in the form of a "blower or sudden outburst." And the same gentleman in his official report as to the Penygraig explosion (101 lives lost), says, "Lastly, I have again to point out, as in the "case of the Risca explosion, the great danger which "attends the use of the Clanny lamp in fiery mines with a "high velocity of ventilation." And again, speaking of the Seaham explosion (160 lives lost), Mr. Wright says:—"If "the view of the proprietors as to the place of origin of the "explosion is correct, this disaster is another instance, "following that of the Risca explosion, of the extreme un- "safety of the Clanny lamp—the Davy is even less safe— "in a rapid ventilation when gas is present. If the other "view is correct, this disaster is another instance of the "urgent necessity for prohibiting the firing of shots when "any large numbers of men are under ground." Then again, Mr. Arnold Morley, M.P., in his official report of the Altham explosion (68 lives lost), states:—"The evidence "confirms what has long been recognised by those who have "had practical as well as those who have had scientific ex- "perience on the subject, and bears out the conclusion arrived "at, from the experiments recently held, that the Davy "lamp, whatever may be its merits for testing purposes, and "in the hands of experienced firemen, affords under circum- "stances which are far from exceptional or unlikely to "occur, very little protection to the ordinary miner while "engaged in his perilous occupation underground."

It may of course be urged that these instances, enumerated, only exhibit the conclusions arrived at by men technically unacquainted with mining; but we must remember that

these gentlemen have been specially trained to sift and weigh evidence, and their technical ignorance is more than counterbalanced by the fact that their minds are free from professional prejudice, and their judgment of the matters brought before them is not so liable to suffer through their thoughts constantly running in old and well-worn grooves.

Then, again, let us see what the Royal Commissioners themselves say on the passage of flame through the gauze of the ordinary lamp. In speaking of the experiments carried out at Garswood Hall Colliery here, in their preliminary report presented to Parliament in 1881, they say: "In the "meanwhile one result was so distinctly elicited, confirma- "tory of what had already been announced by others, that "it was thought right, pending the prosecution of the "inquiry, to announce it to the Secretary of State for "the Home Department. It is to the effect that the em- "ployment of the ordinary unprotected Davy and Clanny "lamps in an explosive mixture, where the current exceeds "six feet a second, is attended with risk of accident almost "amounting to a certainty. It may be as well to add that "the placing of the Davy lamp in an outer case partially "constructed of glass, as now extensively used in Durham, "transforms it from an instrument of the utmost danger, in "a rapid current, into one of great security."

The logic of facts must have convinced mining men that the time has arrived when a radical change, either in the method of ventilating or lighting collieries, is imperative. It is admittedly a difficult question, and when we endeavour to prophecy as to what advice and information the forthcoming report of the Commissioners will supply, we naturally give expression to our own views on the subject.

Now there are apparently two ways of removing the

danger entailed by the present method of lighting, viz., either to slow the ventilating currents passing through the mine below the point at which danger arises, or by the introduction of a lamp so shielded or otherwise arranged as to make it impervious to draught, and thus to nullify any velocity of current. Now it is certainly not probable that the Commissioners will recommend that the speed of the ventilating currents should be reduced, and thus the body of fresh air passing through the mine diminished. If they made any such suggestion, practical miners would not be likely to adopt it, for these latter are well aware that with slow sluggish currents in a seam which gives off fire-damp freely, it is impossible to keep the general atmosphere of the mine comparatively pure, that is, clear of what is technically "cap on the lamp," or so to ventilate the broken parts of the roofs as to keep them clear of explosive gas, and its normal condition would be one, of such peril, that no prudent manager would tolerate. Under such a condition of things, any local explosion of fire-damp, which under more favourable circumstances might have been harmless, would, by reason of the dust and heat set up, extend itself throughout the colliery. Ever since the early days of mining the skill of the mining engineer has been directed to the object of increasing the flow of air in mines, and, in the writer's opinion, this will continue to be his first aim.

If this view is correct, we shall be compelled to fall back upon an improved lamp, and judging from the immense amount of thought and experiment which has been expended during the last few years to produce such a lamp, this opinion seems to be universal; and as to the type of lamp likely to be recommended, it is impossible to specify precisely, but there are some important conditions it must fulfil, the most imperative of these being:—

1st. That it must be self-extinguishing in an explosive mixture.

2nd. That it must be impervious to draught.

3rd. That if glass is used in the construction, it must be so arranged, that the light will be extinguished before it can impinge on the glass when canted sideways.

4th. That it must be strong and simple in construction.

The first condition is imperative, because, in the event of a sudden outburst of gas rendering a district of workings explosive, men and boys often lose their heads, and a stampede ensues, and lamps are liable to be injured and thrown away in the rush to the shaft, and, what is perhaps more important, it renders it impossible for a workman, either knowingly or inadvertently, to place his lamp in an explosive atmosphere whilst he continues his work. The second condition is to provide against any failure of the first, in which latter case gas would continue to burn in the lamp, and if subject to draught, it would eventually fire. The third condition is to provide against the danger of a lamp falling over on its side, or partly over, unobserved by the person using it, and the flame thus impinging on the glass, causing it to crack and sometimes fly to pieces. The fourth condition calls for no comment.

Now, in the absence of any novelty solving, once and for all, this difficult question of safe lighting—and if such a novelty were in existence the news would have oozed out ere this—we are left to select the lamp that fulfils most nearly the conditions enumerated, and, in the writer's opinion, that lamp is the Mueseler. It satisfies the first three conditions entirely, but the fourth it does not meet, and anyone who can simplify its construction, and reduce the number of parts forming the lamp, will confer a great boon on the mining community.

Blasting Operations.

The dangers attending blasting operations in mines will no doubt receive considerable attention from the Commissioners, and their suggestions on this subject are looked forward to with considerable interest, because, during the last few years a startling danger in connection with blasting has been constantly pointed out, viz., that a shot blowing out into an atmosphere partially charged with firedamp, but still much below what has hitherto been considered the explosive point will, on account of the dust particles cast into the mixture by the blast, and the large body of flame emitted, cause a serious and fatal explosion. In other words, that an atmosphere containing something like two per cent. of firedamp, is rendered explosive by the simple addition of a little dust, such as is always to be found in large quantities on the floors of deep dry seams.

In the preliminary report of the Royal Commission this phenomenon is referred to in the following terms:—

"Extensive experiments have been carried on and are still "in progress at Harton Colliery and also at the Broad Oaks "Ironworks, Chesterfield, upon the behaviour of air con- "taining coal dust in suspension and moving at different "velocities, when exposed to the effect of a lamp or gas "flame, or of the flash produced by firing a small charge of "gunpowder in the dust-laden atmosphere."

"The question having been prominently raised during "the inquest which followed the recent explosions at "Seaham Colliery, whether the disastrous results were not "ascribable, at any rate in great measure, to the effects of "dust in the mine, one of your Majesty's Commissioners "undertook, in his distinct official capacity, a series of "experiments at the request of the Secretary of State for "the Home Department, with samples of dust collected in

"different parts of Seaham Colliery. The results obtained "led to an extension of those experiments with samples of "dust from other collieries where serious explosions have "recently occurred, and also with a number of non-com- "bustible dusts."

"Among the points of interest elicited by this inquiry "were the following :—The proportion of firedamp required "to bring dust in a mine into operation as a rapidly- "burning or an exploding agent, even on a small scale, and "with the application of a small source of heat or flame, is "below the smallest amount which can be detected in the "air of a mine by the most experienced observer, with the "means at present in use. In air travelling at a velocity "of 600 feet per minute, different coal dusts suspended in "the air, containing from 2 to 2·75 per cent. of firedamp, "produced explosions. At a velocity of 100 feet per "minute, the same result was obtained with air containing "only 1·5 per cent. of gas, and ignitions of dust approach- "ing explosion and extending to considerable distances, "were obtained with dust in air containing much smaller "proportions of gas. Mixtures of firedamp and air border- "ing on those which will ignite on the approach of flame, "were instantaneously inflamed by a lamp when they "contained only a few particles of dust in suspension, and "it was found that these need not be combustible, but that "some perfectly non-combustible dusts possessed the pro- "perty of bringing about the ignition of mixtures of air "and gas by a lamp flame which were otherwise not "inflammable. We propose pursuing these experiments "still further in certain directions."

Now, the first impression made by such a statement as this must be doubt of its accuracy, because we naturally argue, if this is so, how then do we escape more frequent explosions in mines subject to gas, and where hundreds of

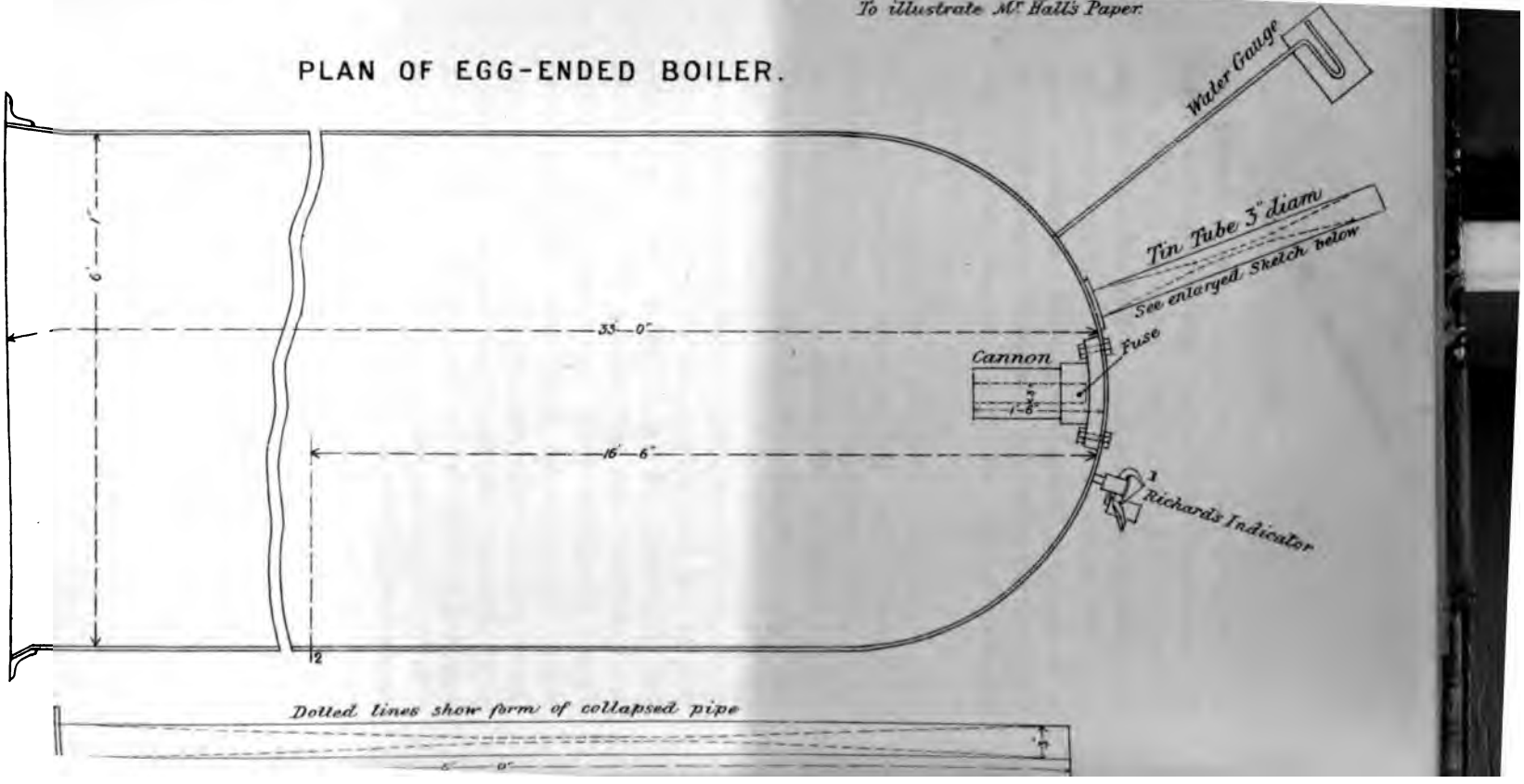
shots are fired daily. But many of us saw the experiments made, and they apparently bore out the conclusions set forth, and we know that they were conducted by a gentleman (Sir Frederick Abel) possessing the very greatest skill, and pre-eminent in such matters, and an authority which cannot be gainsaid. We may rest assured, the facts are as stated, and if there is difficulty in reconciling them with our daily experience, we must look in some other direction for the missing link.

It does seem impossible to believe that shots are not often fired in an atmosphere containing 2 per cent. of firedamp—invisible to the lamp test—as, for instance, in leading places where long lengths of brattice have to be used, and where there is sure to be a considerable emission of gas, and always plenty of fine dry coal dust. How is it, then, that in such places and under such circumstances, explosions do not frequently result. Of course, if the shot does its work properly and casts out little or no flame, Professor Abel would not expect an explosion, but the writer has always been given to understand that "blown out shots" are by no means uncommon in such places, and in all such cases an explosion might fairly be expected; this inference as to the frequency of such shots may possibly be a mistake, upon this point the writer regrets he has no reliable information, but members who are colliery managers can readily clear this up. Of late years, when fatal explosions have occurred, we have usually heard a good deal about "blown-out shots," but more recently we have heard more of failure of lamps.

Now, although it seems difficult to account for explosions not happening oftener if what has been stated is true, yet, on the other hand, assuming it to be true, then we have at once an explanation of many recent explosions, especially in this district, where upon a shot being fired presumably

To illustrate Mr Hall's Paper.

PLAN OF EGG-ENDED BOILER.



after a careful examination by the person lighting it, an explosion has resulted, sweeping through the whole of the workings.

The writer is not aware whether the Commissioners have given any attention to the question of the exhaustive action of charges of gunpowder which blow out the stemming without loosening the coal, already referred to as blown-out shots, but this is a subject which certainly deserves their consideration. The writer, in conjunction with Mr. Pilkington, Mr. Grimkie, and Mr. Glover, made some experiments a short time ago to find the extent of this exhaustive action. A large number of charges of gunpowder (1lb. per charge) were fired from a small cannon attached to the inside of the end of a boiler 36ft. long and 6ft. 6in. diameter, representing a tunnel or working place underground, and on a Richards' vacuum indicator being connected, it was found that a partial vacuum was set up at each shot, and this not only at the end of the boiler, but also along its sides, the decrease of pressure amounting to 3lbs. on the square inch. A strong tin tube 3 inches diameter and 6 feet long was also fixed with its open end entered into the boiler a few inches above the position of the cannon, the other end of this tube being closed and projecting outside the boiler, and on the first shot being fired the tube collapsed to the form shown on sketch, proving that the air had been almost entirely sucked out of it.

Now the action of a blown-out shot must be almost precisely similar to that of the cannon, and the face of coal where it has been planted must be subject to a great exhaustive force, and this will be followed in a fiery seam by an outpour of fire-damp.

There appears to be a strong case for further restrictions as to the use of gunpowder, and we shall no doubt have

suggestions in this direction from the Commissioners, which may assume something like the following form :—

1st. That the use of explosives cannot be dispensed with altogether.

2nd. That the adoption of the Long Wall system of working will in most seams render the use of explosives unnecessary for getting the coal itself.

3rd. That blasting under its most favourable aspect is attended with substantial danger, but when the charge blows out as it not unfrequently does, then there is imminent risk of a serious explosion, if the mine be fiery.

4th. That, as far as possible, blasting should be altogether dispensed with, but in no case should it proceed in mines subject to fire-damp whilst a large number of persons are underground.

ON THE WOLF SAFETY-LAMP AND THE CONTRIVANCE FOR RE-LIGHTING IT.

By C. le Neve Foster, B.A., D.Sc., F.G.S., one of H.M. Inspectors of Mines.

One of the dangers feared in fiery mines is that a safety-lamp may be opened for the purpose of re-lighting it, and so give rise to an explosion. The temptation in some cases is strong. A collier's lamp goes out accidentally in a working place at a considerable distance from the lamp station, and he may have to walk half a mile, three quarters of a mile, or more, and possibly in the dark all the way, before he can have his lamp re-lit, and then he has to make his way back. The time lost in this manner, especially when

the travelling roads are low, is considerable, and as loss of time means less coal got, and a consequent diminution of wages, a reckless man, at the risk of his own life and the lives of his comrades, sometimes opens and re-lights his lamp.

In order to obviate this risk, the legislatures of this and some other countries have prescribed that the safety-lamps shall be locked, and that the men shall not carry keys; and much ingenuity has been displayed in devising various kinds of fastenings so as to render it impossible to open a lamp without detection, and thus to defeat the intentions of unscrupulous workmen who might secrete keys and matches about them.

As far as I am aware, it was not till quite lately that attempts were made to overcome the difficulty from a totally different direction, viz., by supplying a means of ignition within the lamp, and so enabling the workman to re-light it without removing the gauze. My attention has been called to an invention of this kind by the official report* to the Saxon Government of my friends Professors Kreischer and Winkler, of Freiberg, and I think it is important enough to deserve the notice of mining engineers.

The Wolf lamp† which I have on the table is a safety-lamp of the Clanny type, but fed with benzine, instead of colza oil. The benzine reservoir is filled with the best cotton-wool, and is shut off from the central wick chamber by a wire-gauze cylinder. The wick is round, and is carried by a long cylindrical holder, which can be raised or lowered with great nicety by means of a screw passing tightly

* "Untersuchungen über Sicherheitslampen." G. Kreischer and Cl. Winkler. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen auf das Jahr 1884*, p. 30.

† Figures of the reservoir and re-lighting apparatus are given in the Specification, A.D. 1883.—No. 3132. Price 6d.

through a small tube fixed to the bottom of the lamp. A close-fitting cap is screwed over the wick-holder, so that no benzine vapour can escape, except through the wick. The flame is fed therefore like that of a Protector lamp by the vapour of a highly volatile mineral oil escaping at the ordinary temperature from a spongy mass impregnated with it.

The re-lighting apparatus is commendable for its great simplicity. It consists of a strip of paper $\frac{1}{4}$ inch wide and 20 inches long, upon which are fixed 75 patches of a fulminating compound, which will explode with a flash when struck a sharp blow. This strip of paper lies behind a spring, which is pressed out, and then allowed to fly back by simply pushing up a knob at the bottom of the lamp. The same movement brings up a new pellet of fulminate each time. The little apparatus is arranged so that the fulminate is $\frac{1}{4}$ inch from the wick-holder. Though momentary, the flash is sufficient to ignite the benzine vapour surrounding the top of the wick, and the lamp is thus re-lighted.

My colleague, Mr. Willis, has pointed out to me that Wolf's igniter closely resembles Stockwell's* patent lighter for ordinary gas jets. Megill's† patent cigar lighter is a similar contrivance, and Köhler‡ has applied it to benzine lamps. I think it will be admitted that there are advantages in having an apparatus of this kind, not only in the case of the ordinary collier, but also in the case of the fireman, who has to be testing for gas. On the other hand, does it present any danger? The question which arises is this: Supposing a collier's lamp goes out in

* Specification, A.D. 1874.—No. 3782.

† Specification, A.D. 1876.—No. 4427.

‡ Specification, A.D. 1880.—No. 4149. Pollet uses strips of phosphorized collodion in the place of ribbons, with pellets of a fulminate. Specification, A.D. 1878.—Nos. 148 and 2773.

a fiery atmosphere, is there any possibility of his causing an explosion when he re-lights it? In other words, can a slight explosion within the lamp ignite gas outside the gauze? As far as lamps of the Clanny type are concerned, this question is answered by the Preliminary Report of the Accidents in Mines Commission (pp. xii. & xiii.), which says that where a current exceeds 6 feet a second there is a risk of an accident almost amounting to a certainty. I have made some experiments in a rough way by holding the Wolf lamp close to a jet of coal gas, and out of thirty explosions inside the gauze caused on using the igniter, I found that one fired the gas outside. With the present lamp the danger referred to does exist; but there is no reason why Wolf's benzine lamp should not have the double gauze and iron shield introduced by M. Marsaut.

In fairness to Herr Wolf, I must add that both the lamp I am exhibiting, and another with air holes under the glass, are highly spoken of by Professors Kreischer and Winkler, and they consider them well suited for the Saxon collieries, in which the air currents have not very high velocities. They are also of opinion that there is no danger in using benzine, provided that it is burnt in properly constructed lamps,* and they state that it gives a much better, more constant, and cheaper light than rape oil. With a flame 1 inch high the cost per hour is less than $\frac{1}{100}$d. The benzine lamp has the further advantage of being more cleanly in use, the gauze is not soiled by soot and oil, and is more easily kept in perfect order.

In considering the question from all its aspects, it is necessary to enquire whether the use of highly volatile mineral oils, even if we admit their safety in properly constructed lamps, does not introduce a new risk above ground in the room where the filling and cleaning of the lamps is

* *Ibidem*, pp. 3, 38, 41.

carried on. I think it does; but as these operations can be performed by daylight, I see no reason why the lamp trimmer need be exposed to any great danger where proper precautions are enforced. Herr Wolf has arranged an apparatus for filling his lamp safely, and without spilling, but I have not yet seen it.

Though the temptation to open a lamp for the purpose of re-lighting it is removed by the Wolf igniter, the lamp is provided for extra security with a magnetic fastening. The principle of course is not new, but nevertheless Wolf's adaptation of it should not be passed over in silence. The pawl which is drawn back by the magnet is placed inside the thread by which the top is screwed on to the lamp. Consequently there is nothing outside which a workman can tamper with, and the mechanism is thoroughly protected from dirt and injury.

I regret, in conclusion, that it is necessary to call attention to the law with reference to the igniter. An invention of this kind does not seem to have been contemplated by the framers of the Coal Mines Regulation Act, because General Rule 7 says that in any part of a mine in which safety-lamps are required to be used "a person shall not, unless he "is appointed for the purpose, have in his possession any "key or contrivance for opening the lock of any such safety "lamp, or any lucifer match or *apparatus of any kind for* "*striking a light.*" I cannot think that it was the intention of our Legislature to prevent a contrivance such as I have described from being used inside a safety-lamp; but nevertheless, as the Act has to be construed strictly, I am very doubtful whether Wolf's igniter could legally be used in a fiery mine at the present time.

Mr. HALL, referring to Wolf's safety-lamp, said he thought there was no doubt that many a time it had occurred to a collier to try to re-light his lamp without its being taken to the proper station for such purpose, when his light went out and he was a good way from the station. If the danger arising from such a thing could be averted it would be a great advantage; but he understood that Wolf's lighting arrangement had fired some gas outside the lamp.

Mr. GRIMKE enquired whether the same mode of lighting could be employed in lamps that burned oil. He thought there would be considerable danger arising from the storage of large quantities of paraffin.

Mr. BURROWS remarked that it was easy to guard against danger arising from the storage of colzaline, and he pointed out that those who supplied it would do so in tins containing small quantities.

Mr. W. BRYHAM, Junr., observed that in going into deep mines where the temperature was high, it not unfrequently happened that the lights, where colzaline was used, would spring up to a considerable height and thereby create danger of an explosion.

Mr. LONGBOTHAM asked whether it was desirable in any circumstances to give a man the means of re-lighting his lamp when it went out.

Mr. MACALPINE said they had a hundred Protector lamps in use at his colliery, and while they had no difficulty as regards the miners, they found that the drawers were constantly losing their lights. It occurred to him, that the lighting arrangement might be locked so as to put it out of the power of any but the duly authorised person to re-light the lamps that had gone out.

Dr. C. LE NEVE FOSTER, in replying to the questions, said he wished it to be understood that he had no interest

whatever in the lamp which he had described. As to whether the igniter would act in cases where ordinary vegetable oil was used, he had to say that it would not. The cost of affixing the igniters was not great, but the precise amount he could not state. He quite believed that when benzoline or any highly volatile mineral oil was used, great care must be used in storing it and in filling the lamps, but with regard to the cleaning of the lamps, it should be remembered that much less cleaning would be requisite that in the case of ordinary oil. The lamps would be cleaned more quickly and with much less trouble. As regarded the flame increasing when the lamp was placed in a heated atmosphere, he pointed out that the lamp was provided with an apparatus by which the flame could be reduced to any size. With regard to the lamp of the future, he was in hopes that some portable electric light would be devised.

Discussion on both subjects was then adjourned.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XVII. SESSION 1883-4.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 1st day of April, 1884, in the Literary and Philosophical Society's Rooms, George Street, Manchester.

EDWARD PILKINGTON, Esq., J.P., President,
in the Chair.

The following gentlemen were balloted for, and duly elected ordinary members of the Society :—

ANDREW HOWATT, 25, Mill Street, Ancoats, Manchester.

OWEN HUGHES, Colliery Manager, Limehurst, Ashton-under-Lyne.

EDWARD LYON, Colliery Manager, Royton, near Oldham.

JOHN MCADOO, Colliery Manager, Hagside, Radcliffe.

I. PIGGOTT, Colliery Manager, Carlton Villa, Lathom, near Ormskirk.

W. W. SIMPSON, Colliery Proprietor, Church, Accrington.

The PRESIDENT stated that the Council, at its meeting that morning, had adopted a vote of condolence with the widow of the late Mr. J. E. Forbes, one of the Society's Honorary Secretaries. Mr. Forbes was a member of the

Society since 1857, and took a deep interest in its proceedings, having been for many years one of the Honorary Secretaries; and he (the President) was sure members would feel his loss. He moved that the resolution of the Council be approved.

Mr. AITKEN seconded the motion, observing that he had known Mr. Forbes during the twenty years he had been a member of the Society, and always found him very assiduous in the discharge of his duties, and anxious to further the interests of the Society.

The resolution was passed unanimously and the Secretary requested to convey the sympathy of the members to Mrs. Forbes.

MINERS' SAFETY LAMPS.

Mr. DICKINSON said: At the last Wigan Meeting, one of Wolf's Safety Lamps was exhibited, showing an appliance for the re-lighting of lamps without unlocking them. Dr. Foster, who exhibited the lamp, has sent it to me, and I have his permission to show it to the members at this meeting. There are some present, in all probability, who did not see it at Wigan. Dr. Foster describes the appliance as very simple; it is McGill's Cigar Lighter applied to a benzine lamp; but he thinks it has something new in the mode of application.

The PRESIDENT: It has to be a spirit lamp to begin with.

Mr. DICKINSON: It must be a spirit lamp. It is an ordinary spirit lamp—the same as Mr. Teale's.

The PRESIDENT: Is it applicable to other than the Clanny type of lamp?

Mr. DICKINSON: Yes; either Clanny or Mueseler. He exhibited the appliance for re-lighting, and observed that it

must save a good deal of trouble to a miner if he were a mile or two away from the pit shaft.

Mr. MARTIN: At Wigan the question was raised whether it was desirable to give miners the power to re-light their own lamps; and also whether any danger would arise by this means of doing so, which is accompanied by a concussion, in case of its being used in an explosive atmosphere.

Mr. DICKINSON said: The question raised at Wigan, as Mr. Martin has just said, was whether there being a means of re-lighting the lamp in the possession of a person using it would not be an infringement of the Act of Parliament. The Act says that no person is to have in his possession any means for re-lighting a lamp. Now whether the having means of re-lighting it within a locked lamp would be a means "in his possession" within the terms of the Act is a technical point which would have to be settled. There is no doubt the means of re-lighting, such as this lamp possesses, is not, plainly and straight-forwardly, an infringement of what is intended in the Act of Parliament, because it is as much under lock and key as the safety lamp itself; and, looking at the great inducement there is for a miner to unlock and re-light his lamp, in the event of his losing the light far away from the means of re-lighting, I cannot help thinking that there is room for the introduction of a means of re-lighting, such as this, in certain mines where the lighting station is a long distance away, and perhaps a low travelling road to it.

The PRESIDENT: The question is whether, if the lamp was full of an explosive mixture, the re-lighting of it would not cause an explosion outside.

Mr. DICKINSON: There might be a little more risk of the explosion forcing the light to the outside. But no miner would think of re-lighting a lamp in an explosive atmosphere.

A "Safety Lamp," invented and patented by Mr. Harry H. Ford, Park Green, Macclesfield was exhibited and described as follows:—

This lamp is made in a solid cylindrical form, being partly metal and partly half-inch thick well annealed flint glass, which resists force or heat. It is ventilated from the bottom, and so arranged that by a slight motion the air supply is cut off. It is locked by a bolt within the lamp, the bolt being secured by a bar dropping perpendicularly upon it, which bar can only be removed by inverting the lamp, thus drowning out the light, at the same time liberating the bolt.

The inventor claims that by adopting the solid cylindrical form for his basis, he at once strikes at the weak point of all previous productions, and enables him to make a lamp which, up to the present, has resisted every attempt to explode it, many and most severe experiments having failed to effect such a result. That his lock is very simple, and prevents the lamp being opened without extinguishing the light. That the lamp instantly shows the presence of gas, and becomes extinguished when present in explosive quantity. That it gives the maximum of light from an ordinary oil lamp, and cannot be opened without being extinguished.

Mr. Dickinson: Everything that is new has to run the gauntlet of criticism. There has been no objection raised to the principle of the lamp. If the lock should prove not to be sufficient in its present state, it might be altered. I may say that the lamp reminds me somewhat of the Elsin lamp brought out by a Belgian engineer some thirty years ago. That also is a close cylindered lamp; it takes its air in at the bottom—not quite so low down as this,—it takes it in at the flame, and it passes out at the top through a gauze identical with this one.

Mr. Ford: Neither I nor my son, the inventor of the

lamp, ever had a safety lamp of any kind in our hands before this.

Mr. DICKINSON: Your son need not be ashamed of the similarity with the Elsin lamp, as it has passed the standard required by the Belgian Government, and is therefore deemed a safe lamp.

RIPPLE-MARKS IN THE DRIFT.

Mr. MARK STIRRUP drew attention to a recent paper read before the Geological Society of London, by Mr. T. M. Reade, C.E., on "Ripple-Marks in Drift."

In this communication Mr. Reade remarked upon the absence of any description of ripple-marks amongst the published notices of drift deposits, thereby, presumedly, inferring the scarcity or infrequency of such phenomena.

Mr. STIRRUP pointed out that a well marked example occurred in the cliffs near Norbreck, on the north shore at Blackpool.

At the base of the drift-sands belonging to the middle sands and gravels of Professor Hull's classification, and just above the lower boulder clay (from which the deposit in question is separated only by a thin layer of reddish stratified marly clay) occurs a thin stratum of rippled marked sands, which has become lapidified or solidified into a hard sandstone, specimens of which were exhibited.

The ripple-marks are deeply impressed in some places, even to two or three inches.

Mr. STIRRUP also briefly referred to the character of the grains composing this sandstone, and also the loose sands immediately above; many of the quartzose grains being of a rounded character, and showing much abrasion; a subject which has engaged the attention of Professor Sorby and Mr. J. A. Phillips.

THE MINERAL VEINS OF THE LAKE DISTRICT.

By J. D. Kendall, C.E., F.G.S.

INTRODUCTORY.

It is not a little remarkable that, although mining is said to have been conducted in this district since the time of the Romans, so little information exists regarding the nature of the deposits that have been worked. A few isolated pages in the history of the *mining* operations are to be met with in some antecedent publications, but there is almost nothing recorded as yet of a geological character. Even in the excellent memoir by the late Mr. Ward, which professes to give the principal practical results of the geological survey of an important part of this district, the mineral veins are dismissed with little more than a brief notice of their direction and "hade." Mr. Postlethwaite's interesting work on "Mines and Mining in the Lake District," after noticing the principal rock formations and the various minerals found in the mines, is confined almost entirely to a history of the mining operations. Questions of a geological nature seem to have been avoided, generally, in the past. This was probably in part on account of the extreme difficulty of answering such questions, but mainly no doubt it was a consequence of that remarkable indifference or neglect which, prior to the last seven or eight years, seems, in this district, to have characterised the treatment of almost every branch of scientific enquiry.

An investigation into the nature of mineral veins would be very incomplete, if not impossible, without a knowledge of the geological structure of the district in which such veins occur. This part of the subject has, however, been so

well done, for much of the district, by the officers of the Geologieal Survey that only an outline of it will be introduced here, except where further development is necessary to elucidate the special part of this enquiry.

The different rock formations occurring in the district and their chronological relations are exhibited in the following table:—

Recent accumulations.	
Glacial deposits.	
St. Bees sandstone.	*Permians* unconformable to Carboniferous rocks.
Magnesian limestone.	
Breccia.	
Coal measures.	*Carboniferous rocks* unconformable to Silurians.
Millstone grit.	
Yoredale rocks	
Carboniferous limestone.	
Lower limestone shales.	
Conglomerate.	
Kirby Moor flags.	*Silurians.*
Bannisdale slates.	
Coniston grits and flags	
Coniston limestone and Stockdale shales.	
Volcanic series of Borrowdale.	
Skiddaw slates.	
Granite, syenite, &c.	

The area of most of these formations is shown on Plate 1, and their stratigraphical relations are further illustrated by Sections 1 and 2, Plate 2, which are taken through the district, respectively from north to south, and from east to west.

The Upper Silurians, that is, from the base of the Coniston limestone upwards, are fairly conformable to one another, but they are unconformable to the Lower Silurians.

The Carboniferous rocks rest transgressively on the Silurians, and have an average dip of about 20°, outward

from the Lake District. The Permians are spread out over the eroded edges of the Carboniferous rocks, and also dip outward, but at a less angle than the Carboniferous rocks.

True mineral veins have not been found in rocks younger than the Silurians, and even in the upper formations of that age they are rare, almost the whole of them occurring either in the Borrowdale series and the Skiddaw slates, or in the granites and syenites associated with these rocks. It is therefore unnecessary here to notice in detail any of the formations above the Borrowdale rocks.*

The *Borrowdale series* consists of alternations of volcanic lavas and ashes, but the mineral veins hitherto worked in them are confined to the ash-beds. The chemical composition of both these classes of rock is fairly illustrated by the following analyses :—

	Lava.	Ash Rock.
Silica	60·11	69·04
Alumina	16·17	15·17
Lime	5·71	2·15
Magnesia	1·85	0·55
Potash	3·02	3·94
Soda	2·96	4·32
Ferrous Oxide	5·67	2·81
Ferric „	1·33	·30
Bisulphide of Iron	·49	·20
Phosphoric Acid	·19	·27
Sulphuric „	·09	·10
Carbonic „	1·61	·33
Loss on Ignition	·72	·76
	99·92	99·94

The thickness of these rocks has been proved, by actual working at Coniston Mines, to be over 1800 feet, and in the

* For a description of the formations above the Silurians, see the following papers by the author :—

"Hematite Deposits of West Cumberland," Trans. of N. of E. Institute of M. & M. E.'s, p. 13, vol. 28. "Hematite Deposits of Furness," p. 15, vol. 31. "The Structure of the Cumberland Coal-field," p. 15, vol. 32. Also Memoirs of Geo. Survey.

memoir of the northern part of the lake district they are estimated at about 12,000 feet. Their average thickness is, however, probably much less than this.

Both the lavas and ashes are thick-bedded. The former occur most extensively in the hills immediately to the south and east of Derwentwater, whence they thin out somewhat rapidly towards the area occupied by the Upper Silurians. Some of the ashes are very finely cleaved, and make excellent roofing slates, as in Borrowdale, and at Honister, Yewdale, Tilberthwaite, and Walney Scar. The direction of the cleavage, and also the dip of the beds in the neighbourhood of the most important mines, are shown on Plate 1. From an inspection of that plate, and also of Figs. 1 and 2, Plate 2, it will be evident that these rocks have been subjected to great disturbance since they were deposited, especially during Devonian and later Carboniferous times, and since the Permian era. As will be noticed on the map, they are in many places traversed by more recent volcanic rocks, which were probably intruded during some of these periods of disturbance.

The Skiddaw Slates consist of several masses of indurated mudstones, alternating with sandstones and grits, all thin-bedded, particularly the argillaceous strata. They are so much split up by joints as to be of very little economic value.

The mineral veins that have been worked in these rocks seem to be entirely confined to the argillaceous beds, the composition of which is as follows:—

Silica	56·76
Alumina	24·91
Lime	·64
Magnesia	1·32
Potash	3·31
Soda	1·66
Ferric Oxide	6·07
Loss on ignition	4·86
	99·53
Specific gravity	2·64

These rocks, far more than those of the Borrowdale series, have been subjected to subterranean disturbance, as will be apparent on reference to Plates 1 and 2. As a consequence, the dip of the beds is very variable both in direction and amount, as is partly shown in Plate 1, where also the direction and dip of the cleavage is indicated.

The thickness of the Skiddaw Slate is unknown. Various estimates have been made, ranging from 5000 to 10,000 feet; but none of these can be considered reliable, as it is almost impossible to trace the exact succession of beds, on account of the great similarity of most of them in colour and lithological character.

From the way in which the Carboniferous rocks repose, at one place or another, on all the different members of the Silurians, it is obvious that great disturbances of the latter rocks must have been effected in very early times, in part probably before the Borrowdale series were deposited, but mainly, no doubt, during the Devonian period. They have also been subjected to considerable violence since that time, especially at the close of the Carboniferous era, and subsequently to the deposition of the Permian rocks.

It was probably during some of these periods of volcanic activity, that the numerous patches of intrusive rock, met with in this area, were formed.

Eskdale Granite and Ennerdale Syenitic-Granite, &c.— The positions and extent of these rocks being shown on Plate 1, it will scarcely be necessary here to give more than a few analyses of their chemical composition. These are taken from a paper by the late Mr. Ward, on the "Granitic Granitoid, and associated Metamorphic Rocks of the Lake District."*

* *Quarterly Journal*, Geological Society, Vol. XXXI., p. 568.

	Eskdale Granite.	Ennerdale Syenitic-granite.	Carrock Fell Hypersthenite.
Silica	73·573	71·442	56·656
Alumnia	13·750	15·340	16·129
Lime	1·064	1·064	7·068
Magnesia	·396	·720	2·306
Potash	3·512	4·439	1·293
Soda	4·315	3·951	8·296
Ferrous Oxide	2·103	1·107	6·590
Ferric „	·615	1·230	·549
Phosphoric Acid	·012	·118	·153
Sulphuric „	—	trace	trace
Carbonic „	trace	trace	·356
Loss on ignition	·660	·589	·604
	100·000	100·000	100·000

Both the granitic and granitoid rocks, and also the rocks of the Borrowdale and Skiddaw series are traversed by innumerable divisional planes or joints, which, in some places, are nearly vertical, at others they vary from that position as much as 30°. In the stratified rocks these planes may be divided into two sets, the directions of which differ considerably, even within a limited area, but they always cross one another at horizontal angles, varying from 50° to to 80°. In the granitic and granitoid rocks there are three sets of these joints, one of which is probably the equivalent of the bed-joints of stratified rocks.

The foregoing general observations are offered as being mainly essential to a due comprehension of the special subject of enquiry, which will now be entered upon.

Mineral Veins.

The investigation will perhaps be most easily carried out by dividing it into the following parts:—

1. The different kinds of veins.
2. Their Geological distribution.
3. Direction and hade.
4. Length, breadth, and depth.
5. Apparent reciprocal influence of veins and their enclosing rocks.
6. Inner nature.
7. Mineral contents.
8. Age and origin.

1. Different kinds of Veins.

Although, as will hereafter be seen, there are many kinds of minerals found in veins, yet there is in every vein a preponderance of one particular mineral.

Adopting the usual practice, and taking the metallic minerals as the basis of classification, the veins occurring in the district under consideration may be distinguished as follows :—

1. Lead.
2. Copper.
3. Zinc.
4. Iron.
5. Manganese.

According to this classification, a vein, which yields only one of these minerals in workable quantity, would receive its name from that particular mineral. But it sometimes happens that a vein yields two of the above minerals in such quantities that they are both workable. They may be lead and zinc, lead and copper, or iron and manganese. In such cases veins should properly receive compound names, and be designated respectively lead and zinc veins, lead and copper veins, and iron and manganese veins. But the old practice has been to speak of them as lead or copper veins merely, according as one or other of these minerals predominated,

whilst blende, the common ore of zinc in the district, was not until a few years ago known to be a useful mineral, so that its presence in a vein, even when in large quantities, was not indicated by the nomenclature. The vein worked by the Woodend mines, near Threlkeld, yields both blende and galena in workable quantities, but though the former is the preponderant mineral, the vein is usually spoken of as a lead vein. At Red Gill mines, ores of both lead and copper were obtained from the same vein; and at Roughten Gill, lead, copper, and zinc ores were worked together. At Force Crag mine, the principal metallic minerals obtained were ores of lead and zinc. The vein there worked may therefore be considered as a lead and zinc vein. But as, along with these ores, a large quantity of barytes occurred, for which alone the mine was worked for some time, the vein has come to be spoken of as a barytes vein, and is so referred to in Mr. Ward's Memoir.

2. Geological Distribution.

As mentioned in the introductory remarks, most of the mineral veins hitherto worked, occur in the Lower Silurians and in the granitic and granitoid rocks associated with them. Mineral veins have, however, been met with in the Upper Silurians, but they are rare, and, so far as yet proved, not of very great economic importance.

In the Coniston grits and flags, about midway between Stavely and Kentmere, a lead mine was worked for several years, and a considerable amount of work done, but the results were not satisfactory. Other trials were made between Winster and Crook, in the Bannisdale slates, and a small quantity of galena was obtained, but not sufficient to induce the adventurers to continue their work. Explorations on a small scale have also been conducted in other parts of the Upper Silurian area, but the results were equally discouraging.

In the Lower Silurians and their associated rocks, veins are numerous, and some of them have yielded large quantities of minerals.

In the *Borrowdale Rocks* there are the famous copper mines of Coniston, and the equally important lead mines at Greenside, besides a large number of veins of both lead and copper in other parts of the district, many of which have not been worked at all, and others only partially. Veins of hematite are abundant in these rocks, but very few of them have been explored on account of their great distance from the railways. The most extensive workings have been at Tongue Gill, near Grasmere, and at Dunnerdale, in the Dudden valley. It is in these rocks that the Borrowdale graphite is met with.

In the *Skiddaw Slates* veins of both lead and copper occur. Among the mines in which ores of the former metal were worked, it will suffice to mention Loweswater, Goldscope, Yewthwaite, Barrow, Brandlehow, Force Crag, Thornthwaite, and Woodend. Some of these mines, as previously mentioned, worked ores of zinc as well.

The principal copper mines in the Skiddaw Slates are at Goldscope and Dalehead, but there are several other copper veins in these rocks, some of which have not been proved, whilst others have been worked but slightly.

Hematite has been worked very extensively in these rocks for a number of years, at Knockmurton and Kelton Fell, and these are almost the only places where any serious attempt has been made to find it.

Veins of manganese ores also occur in these rocks, but they have not yet been worked, except in the most trifling way.

In the *Eskdale Granite* and the *Ennerdale Syenitic-granite*, the only veins that have been much worked are those of hematite. In the former rock, this ore has been obtained in

Eskdale, on both sides of the valley opposite Boot, and also near the King of Prussia. It has also been worked near Bootle. In the latter rock several veins have been worked, in a small way, near Ennerdale Lake, and it is now proposed to make a railway to them.

In the *Hypersthenite* and its associated rocks, of Carrock Fell and neighbourhood, both lead and copper veins have been worked, notably at the mines of Roughten Gill, Silver Gill, &c.

There does not appear to be a single instance in the district of the same vein having been worked in the granitic or granitoid rocks, and in the sedimentary or volcanic rocks surrounding them. Veins occur between different kinds of rocks, as in Clews Gill, Ennerdale, where a vein of hematite has been partially worked with Skiddaw slate on one side of it, and syenitic-granite on the other. There are several other "contact" veins in that neighbourhood but they have not yet been worked.

3. Direction and Hade.

It is a very common thing to hear lead veins spoken of as having a north and south direction, and copper veins as bearing east and west. No doubt this is frequently correct, but it is not so always, as will be seen by reference to Fig. 3, which has been prepared to enable a ready comparison to be made of the directions of different veins yielding the same kind of mineral. The following details will enable this comparison to be carried still further, the angles of direction being from the true meridian.

Copper Veins.

Goldscope .. .... 72° N.E. and S.W.
Dalehead.. ..... 72° N.E. and S.W.
Coniston .. .... 82° N.E. and S.W., and 48° N.W. and S.E.

Paddyend (Coniston) 83° N.W. and S.E., and 53° N.W. and S.E.

Tilberthwaite .. .. 80° N.W. and S.E., and 80° N.E. and S.W.

Lead (1), Lead and Zinc (2), and Lead and Copper Veins (3).

1. Goldscope.... 25° N.E. and S.W.
1. Greenside .. N. and S.
2. Yewthwaite .. 23° N.W. and S.E. } Generally supposed to be parts of one vein.
1. Barrow .... 23° N.W. and S.E. }
1. Thornthwaite.. 23° N.W. and S.E. }
2. Brandlehow .. 23° N.W. and S.E.
2. Woodend .... 48° N.W. and S.E.
1. Loweswater .. 45° N.W. and S.E.
3. Roughten Gill. 50° N.E. and S.W.

Hematite Veins.

Knockmurton ..... 8° N.W. and S.E., and 60° N.W. and S.E.

Kelton Fell ..... 60° N.W. and S.E.

South Cumberland, Eskdale 73° N.W. and S.E., and 27° N.E. and S.W.

Nabgill, Eskdale ..... 23° N.W. and S.E., and 62° N.W. and S.E.

Manganese Veins.

Wiley Gill ..... 5° N.E. and S.W.

Mosedale..... 45° N.E. and S.W.

Where two directions are given for the same place, they relate to different veins, except, in the case of Coniston, where they refer to different parts of what is known as the Bonser vein.

It thus appears that there is a very great variation in the directions of the veins even when the preponderant mineral is of the same kind. There is also a considerable variation of "hade" both in direction and amount. By reference to

Fig. 3 it will be seen that whereas some veins "hade" towards the east, others have a westerly inclination. The *amount* of "hade" is also very variable, being in some cases nearly plumb, whilst in others it is as much as 35° from the vertical. This will, however, be more clearly seen on reference to the *sections* of Goldscope, Yewthwaite, Coniston, and the Whitehaven iron mines, given respectively on Plates 4, 5, 6, 7, and 8. In the *plans* accompanying those sections the course of the veins is given at different levels, as proved by actual working, so that the variations of "hade" at any part of these veins may be seen at a glance. From the transverse section of the Bonser vein at Coniston mines, Plate 7, it will be seen that near the surface the "hade" is to the south-west. The vein then goes nearly plumb for about 90 fathoms, and in the lower part it hades toward the north-east.

Notwithstanding these great variations in direction and "hade," which at first sight are most confusing, a considerable amount of order may be discerned in them, for on closer inspection it is found that both the *direction* and *hade* of the veins almost invariably correspond with the planes of one or other of the different sets of joints by which the enclosing rocks are intersected. For example, at Goldscope (copper vein), Dalehead, part of Coniston, and Tilberthwaite, the direction and hade of the veins correspond with the strike and dip of the cleavage planes. At Knockmurton a considerable part of one of the veins is coincident with the bed-planes of the rock; other veins at that place correspond with the divisional planes. In the Eskdale granite and the Ennerdale syenitic-granite the veins are invariably on one or other of the different sets of divisional planes; and so throughout the district it is found that they nearly always correspond with either the cleavage or the bed-planes, or with one or both sets of divisional planes.

4. Length, Breadth, and Depth.

If the veins at Yewthwaite, Barrow, and Thornthwaite are parts of one great vein, as they are generally held to be, such vein must be nearly six miles in length, and is undoubtedly the longest known vein in the district. But their identity has not been proved, and the idea is at present a mere suggestion, with nothing more behind it than the fact that the so-called parts are in the same general line. Between Thornthwaite and Barrow more than a mile of unproved ground intervenes, whilst Barrow and Yewthwaite are nearly the same distance apart.

The length actually worked at different mines is a much better guide as to the extent of veins longitudinally. In Plates 4, 5, 6, and 8 some information on this head is given, and more will be found below :—

Length of Vein worked.

	Fathoms.
At Coniston (copper)	320
„ Goldscope „	200
„ Goldscope (lead)	280
„ Greenside „	200
„ Yewthwaite (lead and zinc)	260
„ Brandlehow „ „	280
„ Roughten Gill (lead and copper)	600
„ Nabgill (hematite)	240
„ Kelton Fell „	320

It cannot be said that in any one of these cases the *end* of the vein has been reached, but how much further any of them may go, beyond the points to which the working extended, is very uncertain.

The *Breadth* of veins is variable, some having an average breadth of three or four feet only, whilst others are as much as five or six feet. In the same vein there is, however, a

much greater variation than this, as will be seen in the cross section of the Goldscope lead vein, Plate 4, and below:—

Depth from Surface.		*Breadth of Vein.*		
8	fathoms.	3	feet.	
12	„	12	„	
18	„	10	„	
28	„	5	„	
38	„	3	„	
48	„	5	„	
58	„	5	„	
68	„	4	„	
78	„	5	„	
88	„	6	„	
98	„	10	„	
108	„	32	„	including several "horses" of Country Rock.

These breadths were taken on the line of the shaft, and are given on the authority of Mr. B. Plummer, the manager of the mine at the time it was working. In other veins similar variations are met with. At Kelton Fell one of the hematite veins has in some places been as much as 25 feet wide, whilst at other places it was a mere string. The Greenside vein is said to have been as much as 60 feet wide in some parts. At other places it was not more than a foot or two, and even less.

The extreme *depth* to which veins descend has not been proved. The deepest exploration in the district is at Coniston, where one of the veins has been worked to a depth of 260 fathoms, and is still going down without any apparent indications of nipping out. In fact it is quite as wide now as it was near the surface. The Goldscope lead vein was worked to a depth of 110 fathoms, and it was wider

then than it had been at any other part. The hematite veins in Eskdale have been worked to a depth of 60 fathoms. but they are much reduced in size at that depth. Whether they may open out again at lower depths, as lead and copper veins do, is yet to prove. The low price of hematite, as compared with that of lead and copper, necessarily prevents veins of the former mineral being worked to the same extent as those of the latter, so that when iron veins become narrowed to a size that would still pay well in lead or copper veins they have to be abandoned, and their breadth at lower levels consequently remains unknown.

5. Apparent Reciprocal Influence of Veins and their Enclosing Rocks.

It is a very curious and important fact that the chemical composition of a rock immediately adjoining a mineral vein is in many instances, and it may be in all, different from that of the same rock only two or three feet away from the vein. This statement will be rendered clearer by the following analyses of Mica Schist, adjoining a manganese vein in Wiley Gill, to the north of Skiddaw. No. 1 shows the composition of the rock close to the vein, No. 2 that of rock about three feet away.

Analyses of the Wall-rock of a Vein.

	No. 1.		No. 2.
Silica	64·56	.....	52·23
Alumina	22·72	.....	25·25
Lime	0·20	.....	0·22
Magnesia	0·30	.....	1·74
Alkalies, &c.	6·58	.....	9·09
Peroxide of Iron	2·90	.....	7·05
Water combined	2·74	.....	4·42
	100·00		100·00
Specific gravity	2·62		

In the rock immediately adjoining the vein (No. 1) there is an increase of silica, and a diminution of all the other elements, as compared with the normal composition (No. 2.)

In some places the walls of a vein are softer than usual and quite decomposed, and, almost invariably, where this is so, the vein is extra wide. On the other hand, where a vein is narrower than usual, it is almost certainly found that the walls are extra hard. In some mines it is considered a good indication when the walls become softer.

As already pointed out, the veins hitherto worked in the Skiddaw slates are confined to the argillaceous beds of those rocks, whilst those in the Borrowdale series seem to prefer the ash rocks; but the reason of this may well be that the greater hardness of the sandstones and grits of the Skiddaw slates, and of the lavas of the Borrowdale series, has prevented veins which are known to exist in those rocks from being worked, for it is certain, other things being equal, that a miner will always prefer a soft country rock to a hard one.

The hematite veins in the hard Granitic and Granitoid rocks do not appear, generally speaking, to be so wide as in the softer Skiddaw slate. The widest hematite vein yet found is in the latter rock at Kelton Fell.

6. Inner Nature.

When veins are examined internally it is found that they are divisible into two classes—

1. With veinstone.
2. Without veinstone.

The first class includes veins of lead, copper, and zinc. The second class comprises those of hematite and manganese.

The greater part of the veinstone found in veins of the first class consists invariably of quartz, of which there are several varieties, some having a glassy texture, others being finely or coarsely granular, but all are mostly milk-white,

small portions of them being stained various shades of yellow. Some of the varieties are occasionally cellular, others assume the form of small incoherent angular grains, or, if coherent, the uniting material is frequently either an ore of iron or manganese. The composition of vein quartz is shown by the following analysis of a piece from Brandy Gill, Carrock Fell.

Analysis of Quartz Veinstone.

Silica	98·02
Alumina	0·95
Peroxide of Iron	0·97
Manganous Oxide	trace
Lime	0·20
Magnesia	trace
	100·14
Specific gravity	2·56

Veinstone occurs in two ways. In one it extends from "cheek to cheek," as in Fig. 9, which is a cross section of part of one of the Red Gill veins. At other times it occurs in strings of varying breadth, which form a kind of network in the rock, as seen in Fig. 10, which is a cross section of Benson's south vein, Tilberthwaite. All the veins about Coniston are of this class, and some of them present a most complicated appearance, as may be partly learned from Fig. 11, which represents a portion of the veinstone from the Bonser vein. Similar appearances are frequently met with in other mines. Figs. 12 and 13 are representations of a portion of veinstone from Yewthwaite and Goldscope respectively.

At Brandlehow mine, in addition to the ordinary quartz veinstone, a considerable quantity of Dolomite was met with interlacing the rock, as shown in Fig. 14. This mineral has also been frequently met with at Coniston mines, especially

in the Paddyend portion, where at times it forms a rib six or eight inches thick on one of the walls; but more frequently it ramifies the veinstone and rock as at Brandlehow. In the Bonser vein it is mixed up occasionally in a most irregular way with the quartz, and also with the metallic minerals associated therewith.

Barite is also found in many veins, sometimes, as at Force Crag, in large quantities. It appears mostly to occupy pre-existing loughs, and to have been introduced subsequently to the metallic minerals, as will be explained hereafter.

The principal metallic minerals appear in veins in various ways; sometimes they occur in "spots" or "blotches" in the veinstone, as shown in Fig. 9, or as is more particularly delineated in Fig. 15, which is a full-size representation of a portion of veinstone with galena from the vein shown in the former figure. Fig. 16 shows the occurrence of chalcopyrite and galena together in the same vein. Fig. 17 will give some idea as to how that ore is frequently met with at Coniston mines, the "blotches" being larger and more irregular than at Red Gill. This spotted and blotched appearance is by far the commonest form in which ores occur in the veins of this district. Less frequently they appear as "ribs" in the veinstone. In one vein or another "ribs" have been found of all breadths up to 18 inches. In some cases several such "ribs" occur side by side, separated only by a few inches of "sugar spar." This was so in several parts of the "great lead bunch" in Goldscope mines, where the ribs in places had an aggregate thickness of about six feet. Similar masses of ore have also been worked at Greenside. These "ribs" are always parallel to the walls of the vein, and as a rule they do not continue far either horizontally or vertically; in some cases only a few yards, until they begin to thin off and die out altogether. In this respect they differ widely from the "spots" and "blotches" which are frequently found

throughout great lengths and depths, although they likewise are much poorer in some places than others, and are often absent altogether. The unequal way in which ore is distributed in a vein will be best understood by reference to the longitudinal sections on Plates 5 and 7, in which the richer portions of the vein are shown by darker shading; the lighter portions containing so little ore that they were not considered worth working, and were not worked.

At times ore assumes the form of "bunches," either in the quartz, or between the quartz and the country rock. In the Goldscope lead vein one of these "bunches," according to Mr. Plummer, contained about 50 cubic yards of solid galena.

The only other form in which ores occur in this class of vein is as irregular strings which branch out from the vein into the cheeks, as shown in the hanging wall in Fig. 9, a full-sized representation of a portion of which is given in Fig. 18. A further illustration of this mode of occurrence is shown in Fig. 19, it is from the wall of a lead vein at High Nook, Loweswater.

All the metallic minerals, such as chalcopyrite, galena, pyrite, and blende, that occur most abundantly in veins, appear in the same way, that is as just described, although, as already mentioned, some are much more abundant than others.

The *space* occupied by the metallic minerals in veins of this class is very variable, if it be considered in relation to the full width of the veins, but its ratio to the veinstone alone is not so variable; the reason being that some veins contain a larger proportion of country rock than others. It will perhaps not be far from the fact to say that the bulk of the metallic minerals in a vein never exceeds 20 per cent. of that of the quartz veinstone. The non-metallic minerals—quartz excepted—are perhaps always under 10 per cent. of

the quartz. The comparatively small space occupied in veins by the metallic minerals will be most readily understood from one or two examples. The Goldscope mine was considered to be one of the richest lead mines in the Lake District, that is in proportion to its extent, for, as will be seen on reference to the longitudinal section, Plate 4, the principal ore-bearing portion of the vein was very short. The total quantity of ore put out of the mine down to the 60 fathoms level was 4100 tons. This is equal to a rib of barely three inches in the thickness throughout the area of vein worked.

The ore yielded by the Yewthwaite vein was much less, being only equal to a uniform rib of ·85 inch in thickness.

The Coniston and Paddyend veins contained chalcopyrite equal to a continuous solid rib 8¼ inches wide.

The productive parts of veins, or "ore runs," as they are sometimes called, are at times separated by portions that are quite barren, which contain very little veinstone, and are almost exclusively occupied by a clayey substance, which is locally called "douk." The vein on each side of the "great lead bunch," at Goldscope, was of this character, as were also parts of the Roughten Gill vein and the Greenside vein. In other cases, the poverty of a vein arises from the relative absence of veinstone, and the closing together of the walls until they almost touch one another. This is usually the case at the inferior parts of the copper veins of Coniston.

It is generally found that the walls of a vein are very well defined (as in Fig. 9), and that there is a clear line of demarcation between the contents of the vein and the enclosing rock. In other cases, as in Fig. 20, which shows part of Paddy End vein, Coniston, only one of the walls is clearly defined, the other side of the vein being very irregular, and graduating into the country rock, so that when the vein is worked, part of the country rock on that side has to be taken away with it, until a joint, such as is shown in the figure, is

reached. In the unproductive part of the Goldscope lead vein they had only one wall—the "lying wall." The other was said by the manager of the mine to have been "lost" in the country rock. Occasionally both walls of a vein are very indistinct, and when this is so, it is generally found that the vein is very poor, containing little veinstone, and that so much scattered that it is a matter of considerable difficulty to say which is and which is not the vein. Under these circumstances, miners are very often at a loss to know which way to drive, and they not unfrequently find, after following some of the scattered quartz strings for a time, that they have left the vein altogether. It then becomes necessary to turn across to the right or left, or go back again to the point where the uncertainty began.

Veins are occasionally intersected by faults, which are of various sizes, some, known to miners as "slides," are but small, and shift the vein only a foot or two, or at most eight or ten feet to the right or left. Several of these may be seen in the Bonser vein, Coniston. Others like the "great cross course" at those mines, cause a displacement of the veins for a great many fathoms, so that it becomes a matter of some difficulty to find them again.

Another of the more prominent features of veins is the occurrence in them of irregularly-lenticular pieces of country rock, standing on edge, the largest of which are by the miners called "horses." Usually these pieces of rock are not more than from two to six feet wide, and only a few fathoms long at most; occasionally they are much larger than this, so that for a time it is difficult, during the progress of the mining operations, to say whether or not the vein is permanently splitting into two. They all have the same "hade" as the veins in which they occur, and their planes of lamination are invariably parallel to those of the rock forming the "walls."

In some veins "loughs" are occasionally met with, sometimes in the veinstone, at others between the veinstone and the wall-rock, and occasionally they are entirely in the wall-rock. They have been seen of all sizes up to 12 or 15 feet and even more in length, 5 to 8 feet in depth, and 2 to 3 feet in breadth. In rare instances they have been met with 20 to 30 fathoms long. Their breadth and depth then did not, however, exceed those of the shorter loughs. The smaller loughs are very irregular in form, but the larger are approximately lenticular in shape, their longer axes corresponding with the direction of either the length or depth of the vein, and when they can be said to have a "hade" it invariably coincides with that of the vein. The walls of these loughs are mostly coated with crystals of different minerals. Here it is that the rarer minerals found in veins are mainly met with. Some of the loughs contain irregular fragments of wall-rock cemented together by quartz, thus producing the appearance of a breccia. The fragments are only small but their planes of lamination are in all directions.

A microscopic study of the different parts of veins reveals the following facts. If a piece of veinstone spotted with galena, for example, be examined by transmitted light there is seen to be a distinct line of demarcation between the metallic mineral and the enclosing quartz. The "spots" have exactly the same forms as the cavities of cellular quartz, and they do not in the least seem to have been influenced in their outline by the crystalline form of the metallic mineral. Slices of country rock taken from a vein exhibit some most interesting phenomena, especially if there be present spots or strings of any metallic mineral. In examining by the unaided eye a piece of Skiddaw slate spotted with galena, similar to that shown in Fig. 19, there is not anything remarkable in the appearance of the slate,

except that it seems a little paler than usual. But, when placed under the microscope, in a thin slice, it is found to be traversed in a most curious manner by fine reticulate seams of quartz, which graduate into the slate in such a way as to suggest that they are the result of metamorphic action on the latter. Between the slate and the spots or strings of galena included in it, there is everywhere a band of quartz, which is of variable breadth and graduates into the slate, but not into the galena, its limit on that side being clearly defined. In the same way, when a rock is traversed by vein-quartz, as in Figs. 11, 12, and 13, it is found, under the microscope, that there is not the clear line of demarcation between the two substances which, to the unaided eye, there seems to be, but that they graduate into one another. When quartz crystals are attached to slate, there is the same internal connection. The crystals do not appear to have been formed on the slate, but out of it.

The hematite and manganese veins are much simpler in their inner nature than those just described. Their general form is represented in Fig. 21, which is a cross section of a manganese vein at Knott, on the north side of Skiddaw.

The chief peculiarity of veins of this class is the absence of veinstone, otherwise they present most of the features seen in veins of lead, zinc, and copper. There are the "horses," the "loughs," and occasionally the indefinite walls above alluded to, but, in consequence of the absence of veinstone, the distribution of the metallic minerals is different. The bulk of the ore in the hematite veins that have been worked occurs in one or more ribs of variable width, which appear interruptably both lengthwise and vertically. They sometimes occupy the full width of the vein. In other cases they are narrower, and when this is so the ore is mainly found against either one or both of the walls, the remainder of the veins consisting of country rock,

more or less intersected by strings and small bunches of ore, as shown in Fig. 22, which represents a piece of granite found in the position just indicated in one of the veins in the granite opposite Boot, in Eskdale. Examples of all these modes of occurrence may be seen in the South Cumberland mines, Eskdale, and in the Crag Fell mines, Ennerdale. The rock immediately adjoining such veins is frequently stained and interlaced by strings of ore similar to those shown in Fig. 22; a curious occurrence of this kind being exhibited in Fig. 23, which was drawn from a piece of rock found in Burdell Gill, north of Skiddaw. The proportion of ore in veins of this class is much larger than in those containing veinstone. Whereas, in the latter, the metallic minerals never exceed 8 or 10 per cent. of the workable part of the vein, in the former they have been known to occupy as much as 60 or 70 per cent.

Manganese veins are not common in the district, and only one or two have been but partially worked, so that it is not possible to say much about them. But the ore seems to occur in them much in the same way as hematite is found, being sometimes confined to a narrow strip along one wall, at other times extending completely across the vein, as shown in Fig. 21.

In these veins the variety of minerals found is nothing like so great as in those of lead, zinc, and copper. Beside the ores of iron and manganese, which they yield, there is rarely any other mineral found in them but dolomite, quartz, and calcite, all of which occur in crystals, but the first is found amorphous as well. Fig. 24 represents a piece of hematite and dolomite from one of the veins in the Eskdale granite, and Fig. 25 shows the same minerals and their relation to the country rock of a vein in the Borrowdale series near Gate Crag, also in Eskdale. In some of the veins in that neighbourhood dolomite occupies a con-

spicuous place, being, in fact, at times more abundant than hematite.

Although ores of manganese and iron frequently occur in the same vein, so that wherever a deposit of manganese is met with it contains more or less iron in some form or other, yet the hematite veins yield scarcely any manganese unless it be a small quantity disseminated through the iron ore.

In taking a general view of the inner nature of mineral veins, no matter whether they have veinstones or not, a close observer will not fail to see the apparently semi-stratified form assumed by everything in the vein. The "horses," the "loughs," the "ribs" of mineral, and even occasionally the spots and blotches, all have approximately the same "hade" as the vein. This is very well seen in some of the pits sunk on the back of the Nab Gill vein, in Eskdale. It is also exhibited, although less distinctly, in the back of the Goldscope copper vein, where, as at the Panholes, some of the vein has been worked away at the surface.

Some veins, such as that in Clews Gill, between the Skiddaw slate and syenitic granite, are doubtless on the lines of faults, whilst others may be, but it is not at present possible to prove whether this is so or not, on account of the great lithological resemblance of the beds in the neighbourhood of most veins. There is certainly not any appearance of faulting in the productive part of veins, except occasionally when, on one of the walls, a thin parting of clay or "douk" may be seen. This seldom exceeds an inch or two in thickness, in which respect it differs greatly from the crushed material accompanying most undoubted faults of any size. Large faults are frequently several yards wide, and seldom less than a yard. The *unproductive* parts of veins that are filled with "douk" bear a strong resemblance to the effects of faulting.

7. Mineral Contents.

In dealing with this part of the subject it may perhaps be as well to retain the distinction made above of veins with and without veinstones, for, as will presently appear, by far the greater number of minerals met with in the veins of this district are from those containing veinstone.

Minerals found in Veins (with Veinstone).

Non-metallic Minerals.	Where Found.
Calcite	As crystals in the loughs of some veins at Coniston and elsewhere.
Arragonite	In loughs at Brandlehow, somewhat rare.
Dolomite	In small quantities in most veins.
Barite	Frequently in veins of galena and blende.
Apatite	In Caldbeck district, uncommon.
Quartz	In all veins—both amorphous and in crystals.
Saponite	Coating calcite and chalcopyrite at Coniston.
Metallic Minerals.	
Limonite	With galena at Loweswater, and elsewhere on the "backs" of veins.
Siderite	At Force Crag, coated with barite.
* Ilmenite	Carrock Fell.
* Pharmocosiderite	Caldbeck Fells.
Pyrite	Common in most lead and copper mines.
Marcasite	Woodend.
Arsenopyrite	Goldscope and Dalehead.
Pyrrhotite	Coniston, with chalcopyrite.
Magnetite	Abundant at Coniston with chalcopyrite and traversed by dolomite.
Manganite	Uncommon, traversing barite at Force Crag
* Psilomelane	Roughten Gill and Dry Gill.
Wad	Skiddaw and Blencathra
* Erythrine	Force Crag.
Smaltine	Coniston and Force Crag.

Chloanthite....Coniston with carbonate of lime.
* Melaconite ..Roughten Gill
Malachite ....Rare in some copper veins but commoner in others.
* Olivienite.. } Roughten Gill.
Brochantite.. }
Chrysocolla....Red Gill, Roughten Gill, and Goldscope.
* Chalcosine ..Red Gill and Roughten Gill.
Chalcopyrite ..Rather rare in most lead veins, but common in copper veins.
* Molybdine.. }
Molybdenite.. }
Wolframine.. } Carrock Fells.
Scheelite .... }
* Wolfram .. }
* Antimonite ..Bassenthwaite and Helvellyn, rare.
* Native Bismuth .... }
* Bismuthine } Carrock Fells.
Tetradymite.. }
Cerussite.....Common in some lead veins, rare in others.
Anglesite.... }
Linarite .... }
Leadhillite .. }
* Caledonite.. } Red Gill and neighbouring veins.
Pyromorphite }
Mimetite .... }
Stolzite .....Found only at Force Crag.
Galena.....Somewhat rare in copper veins, plentiful in lead veins.
* Calamine .. }
* Aurichalcite } Roughten Gill.
* Smithsonite }
Blende.....As a rule common in lead veins, but rather rare in copper veins.

Without Veinstone.

Non-metallic Minerals.	Where Found.
Quartz.....	As crystals in the loughs of most veins.
Dolomite.....	In Eskdale, as shown in Figs. 24 and 25, and at Kelton and Knockmurton in loughs.
Calcite.....	As crystals in loughs, rather rare.
Metallic Minerals.	
Hematite.....	Amorphous and as crystals of specular iron in most veins.
Pyrolusite	Amorphous and in crystals } Wiley Gill.
Manganite	„ „ „ }

The minerals and localities marked thus * are given on the authority of Mr. Bryce Wright and Mr. J. Postlethwaite. They are all uncommon and occur only in small quantities.

The association, in veins, of the more abundant metallic minerals will be best illustrated by a short statement of the principal ores found in a few of the veins that have been most extensively worked.

Name of Mine.	*Principal Ores.*
Coniston	Chalcopyrite, Pyrite.
Tilberthwaite	„ „
Yewthwaite	Galena, Blende.
Force Crag	„ „
Woodend	„ „ Pyrite.
Roughten Gill.....	„ Chalcopyrite.
Greenside.....	„

Pyrite is very common in copper veins. It is the decomposition of this mineral which gives rise to the snuffy brown colour of the veinstone from copper mines, after it has been on the surface a few years, as at Goldscope and Dalehead.

Limonite, which is sometimes called "Gossan," is occasionally found in large quantities on the "back" of veins,

which have the prevailing direction of copper veins. It is quite cellular and streaked and spotted with quartz, being clearly an alteration-product, probably from pyrite. An analysis of some of this gossan is given below:—

Limonite from back of East and West Vein.

Combined Water	14·86
Peroxide of Iron	71·15
Alumina	1·67
Manganous Oxide	0·41
Lime	trace
Magnesia	0·12
Phosphoric Acid	0·25
Sulphuric „	0.05
Insoluble Siliceous matter	11·49
	100·00
Metallic Iron	49·80

"Gossan," an oxide of iron but not limonite, is also found in the interior of veins in small quantities, generally along lines of jointing, or lining small cavities.

Small quantities of the ores of nickel and cobalt have been met with at Coniston along with chalcopyrite, and about half a ton of each has already been sold.

When the more frequently occurring minerals are examined in certain relations it becomes quite evident that they have been introduced to the veins at different times, and their formation appears to have preserved a somewhat definite order in the different veins. It is clear, if one mineral is found coating the crystals of another mineral, that the latter must be the older; or, again, when one mineral is traversed by strings of another there can be no doubt that the latter is the younger. Now, adopting this method of observation, the following facts may be recorded:—

Barite is found on crystals of quartz, blende, and galena.
Blende „ „ galena and quartz.

Pyrite is found	on	crystals of	galena, blende, and quartz.
Chalcopyrite	„	„	galena and quartz.
Galena	„	„	blende very rarely.
Quartz crystals	„	„	blende, pyrite, galena, and chalcopyrite.

Again, barite, pyrite, and quartz are each found in fine threads in blende, and so it is sometimes found that galena traverses chalcopyrite.

The result of an examination of this kind appears to be that the main body of these minerals was introduced to the veins in the following order :—

1. Quartz.
2. Chalcopyrite.
3. Galena.
4. Blende.
5. Pyrite.
6. Barite.

This order has not been tested in all the mines, but it holds good for many of them. As shown above there are departures from it occasionally, as, for example, where galena is found on blende, or again where chalcopyrite appears on galena, but these exceptions are not of frequent occurrence, and only go to show that although the bulk of the minerals were deposited in the order mentioned above, yet small quantities of some of them, at any rate, were deposited at other times. Quartz, for example, was deposited mainly before any of the metallic minerals, but it was also introduced after them, as is shown by the fact that threads of quartz are found in some pieces of blende, and "loughs" in the latter mineral are sometimes lined with quartz crystals. Moreover, quartz is found in crystals on galena, pyrite, and chalcopyrite. The more recently deposited quartz is usually less milky and more glassy than the other, and is, as a rule, in crystals, whereas the first formed quartz is amorphous.

The metallic yield of the principal ores is as follows: —

Chalcopyrite is very variable in its yield, ranging between $2\frac{3}{4}$ and 18 per cent. of metallic copper.

The *Galena* contains metallic lead in quantities varying from 60 to 75 per cent., and some of it is very rich in silver, 11 to 12 ounces per ton being common, and the Roughten Gill ore is said at times to contain as much as 35 ounces of silver per ton of galena.

The yield of zinc from *Blende* may be taken as between 40 and 47 per cent.

Below are complete analyses of some of the ores from the hematite veins, and also of one of the ores of manganese:—

	Nab Gill, Eskdale.		*Kelton Fell.*	
	(1.)	(2.)	(3.)	(4.)
Ferric Oxide	92·57	27·43	80·22	69·14
Manganous Oxide	0·02	0·03	0·04	0·06
Alumina	0·88	6·10	0·26	2·00
Lime.....	0·50	23·10	1·64	0·88
Magnesia	0·08	9·04	0·03	—
Phosphoric Acid.....	0·03	0·04	0·03	0·05
Sulphur	0·01	0·02	traces	0·03
Insoluble Siliceous matter..	2·05	2·15	16·17	22·52
Carbonic Acid and Water..	3·70	32·00	1·20	5·20
	99·84	99·99	100·12	99·88
Metallic Iron	64·80	19·20	56·15	48·40

No. 1 was dried at 212° F.

Pyrolusite from Wiley Gill.

Water combined	3·86
Alumina	2·18
Binoxide of Manganese	65·53
Protoxide of „	23·33
Lime	trace
Magnesia	3·74
Phosphoric Acid	0·62
Sulphuric „	0·02
Siliceous matter	0·72
	100·00
Metallic Manganese.....	59·50

8. Age and Origin.

This part of the subject being necessarily of a conjectural and argumentative character it might have been advantageous to have examined the conclusions arrived at by others before indicating those that seem to be deducible from the foregoing facts. But, unfortunately, such opinions have not been recorded for this particular district. As, however, there is no great difference between the mineral veins of the Lake District and those of other areas, it may not be amiss to consider for a while some of the more important opinions held by writers on the theory of mineral veins in general, so as to see how far such so-called theory succeeds or fails in explaining the facts hereinbefore described.

The general opinion hitherto held seems to have been that *mineral veins are filled fissures.* This was the opinion of Oppel (about 1750), Pryce (1778), Werner (1791), Carne (1822), De la Beche (1853), and of a number of other writers at intermediate dates, whilst the same idea is set forth in Geikie's recent (1882) Text Book of Geology.

The varying width of veins has been attributed generally to the *sliding of the sides thereof upon one another.*

De la Beche, at p. 668 of his "Geological Observer," second edition, says,—"Proceeding to examine the filling of cavities and fissures of larger dimensions, and such as, not confined to minor volumes of rocks, can be traced for considerable distances, and the depths of which are unknown, an observer will have not only to bear in mind the incrustations of the sides of such fissures by the substances which, passing amid the pores or small fissures of rocks on the minor scale, are ready to fill up or encrust any cavities presenting themselves, no matter of what kind or how formed, but also to consider the kind of substances, and their mode of action upon each other, which may be derived from

various distances and sources. Viewing a considerable fissure in its simple form, somewhat vertically traversing various beds of dissimilar rocks, each affording some different or variously combined matter and solution, and confining his attention at first to solutions, the geologist has a more complicated problem presented to his attention than the mere infiltration of mineral matter through the pores of rocks into small cavities and fissures in them. He has to regard not only the probable combinations and decompositions affected by a mixture of substances introduced into the fissure, but also the motion of the whole of the liquid in it according to temperature. The fissure may either be one through which waters rise to the surface of the land and overflow it, thus discharging large volumes of water containing mineral matter in solution of various amount and kind, or the liquid may merely rise to such a height in the fissure as to remain confined to it and the portions of rock adjacent, amid the pores and interstices of which it may also enter. According to temperature, also, will he have to bear in mind the solubility or deposit of the matter generally in the liquid, permitting some of it to remain in solution while other parts were deposited coating the walls of the fissures."

Cotta, at p. 26 of his "Treatise on Ore Deposits,"* says,—"Veins are aggregations of mineral matter in fissures of rocks," and at p. 35 there is the following statement with reference to the breadth of veins:—"The breadth of each separate lode is frequently very variable in different portions. This dissimilarity is a consequence of slides, which the enclosing walls of the fissure have undergone, whereby every deviation of the fissure from a plane would cause a widening or narrowing of the same."

At p. 591 of Geikie's "Text Book of Geology" it is

* American edition, 1870.

stated that "a mineral vein consists of one or more minerals deposited within a fissure of the earth's crust." . . . . "Considerable variations in breadth may be traced in the same vein. These may be accounted for either as due to unequal solution and removal of the walls of a fissure, as in the action of permeating water upon a calcareous rock; or to the irregular opening of a rent, or to a shift of the walls of a sinuous or irregularly defined fissure."

In taking a general view of mineral veins one of the first objections to the foregoing explanations that must rise in the mind of every miner is the impossibility, so far as his experience goes, of the walls remaining intact and apart whilst the vein matter was being deposited. This difficulty can only be properly appreciated by those who are acquainted with vein-mining, and who, therefore, know the great tendency of vein-walls to close together, and also the liability of the "hanging" wall to break and fall away. The "back" of the Goldscope copper vein above the adit was, at one place, worked away to "day." This place is known as the Panholes, and is shown on Plate 4. The breadth of the vein originally worked out, near the surface, would be about 3 feet, and its length about 40 yards, and although this length is a trifle compared with the open spaces there must have been in some veins, if the fissure explanation be correct, yet such has been the effect of the atmosphere and other denuding agents on these walls at the Panholes that large masses of rock have fallen away from the higher part of them and completely blocked up the opening that previously existed below. The fallen pieces of rock being jammed in between the walls have no doubt prevented those walls from falling away as far as they otherwise would have done, but sufficient has already taken place to show that there never could have been a pre-existing fissure where the vein now is. Similar facts may be witnessed in almost

any extensive mine that has been abandoned for a few years. The difficulty of keeping the walls apart at Goldscope is referred to by C. Twite in his report to the Commissioners appointed to enquire into the condition of all the mines of Great Britain, wherein he says "the ground is very difficult to keep open after the lode is worked away, requiring heavy timber."

A further objection to the fissure idea is presented by the "horses." The planes of lamination in these pieces of rock are always parallel to those of the wall rock. Many of the "horses" are, moreover, entirely surrounded by veinstone, as shown below, Fig. 26, a position which it is impossible they could have occupied if they had fallen from the hanging wall of a fissure, for under such circumstances they must have dropped on to the "lying" wall, as represented in Fig. 27.

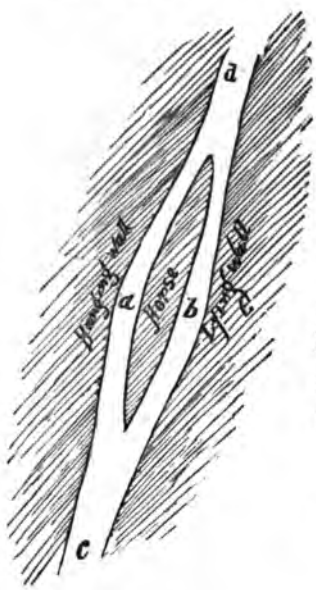


Fig. 26

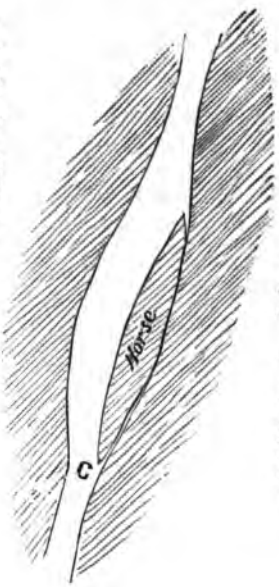


Fig. 27.

Fig. 28.

Other objections than these might be made, for example, unless it be assumed that at the time the "horse" fell the fissure had been filled just up to the level of C Fig. 27, there would be nothing then to prevent the "horse" from sliding down into the position shown in Fig. 28. It may be said that the filling of veins was not effected by the deposition of material from the bottom upward, but from the sides towards the centre. In that case it might be assumed that before the "horse" fell a certain thickness of veinstone had been deposited on the "lying" cheek, and also on the "hanging" side of the "horse," so that the latter could never get into the position shown in Figs. 27 and 28. But even if that were so, there still remains as much difficulty as ever in accounting for the actual position of the "horse" as shown in Fig. 26. It is very well known to miners that the veinstone on each side of a "horse" (*a* and *b* Fig. 26) is often quite as wide as that in the vein above and below it (*c* and *d* Fig. 26.) In those particular cases, therefore, it is quite clear that the "horse" cannot have fallen. How, then, is the space between it and the "hanging wall" accounted for? That it was not caused by a second fracture is certain, otherwise the width of the vein both at *c* and *d* (Fig. 26) should have been equal to the sum of the widths of *a* and *b*. This is, of course, on the assumption that there has not been any sliding of the walls vertically, and that there has not been any such movement, in some cases at least, where the facts recorded in Fig. 26 may be exactly paralleled, is abundantly clear. Take, for example, the Bonser vein at Coniston, a cross section of which is given in Plate 7. It is impossible there can have been any vertical sliding in that vein, for reasons which must be at once apparent to everyone. Yet "horses" have often been met with there exactly as shown in Fig. 26. In the same vein, too, that is the Bonser vein,

considerable variations of width are met with, a fact which proves that such variations are not the result of vertical sliding, as generally supposed, for it is certain that if there has been any movement at all of the walls of this vein it has been lateral and not vertical.

One of the best proofs that the variations in the width of a vein are independent of vertical sliding is to be found at p. 678 of De la Beche's "Geological Observer," although there used for another purpose. It is a section across the lode at Wheal Alfred Guinear, and is reproduced below in Fig. 29.

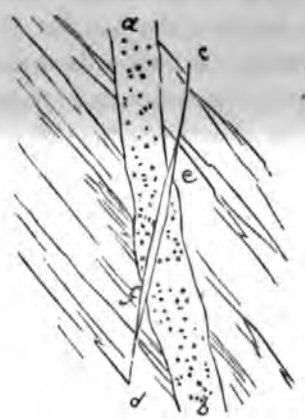


Fig. 29.

REFERENCE.—*a b*, Elvan dyke, 300 feet thick, intersecting slate. *c d*, lode, 6-9 feet wide, above Elvan, 25 feet in latter and 10 feet in slate below Elvan.

It is quite clear that the great increase in the breadth of the lode whilst it is in the Elvan is not due to any sliding of the vein-walls upon one another, because there has not been any such sliding, as shown by the unbroken course of the Elvan.

The occasional indistinctness of the walls of veins is another fact which is inexplicable on the supposition that they once formed the sides of a fissure on which the vein-

stone was deposited. Surely, if such had been the case, there could not have been the least difficulty in pointing out the exact plane on which the deposit commenced.

But there is a far greater objection to this fissure or fracture explanation in its application to the veins under consideration than any of those just mentioned. It is perfectly evident from the section exhibited in Fig. 10 that any single fracture would not account for such a vein as is shown there, and it is quite as certain that any number of possible fractures when filled could not produce that irregular network of quartz. Such, however, is the commonest form of the veins of this district. Again, the impossibility of accounting for such appearances as are shown in Figs. 11, 12, and 13 by the assumption that quartz has been deposited in pre-existing fractures will become more and more manifest as the matter is further considered. Yet such complicated relations of veinstone and country rock are of the most frequent occurrence.

Between a vein as a whole, and any of its parts, such as are shown in Figs. 11, 12, and 13, there is so much resemblance that it is more than probable they were both formed in the same way and at the same time. Now the parts referred to clearly did not result from the filling of fissures, and it is just as obvious that the veins as a whole were not so formed. The difference between quartz strings traversing small pieces of rock, and powerful veins intersecting extensive areas of country, is not one of kind but simply of degree, so that it would be irrational to assume them to have originated differently, unless there were evidence necessitating such a course, which there is not.

This consideration, combined with the arguments already adduced, must, it is submitted, shake the faith of the most ardent believer in filled fissures, and such a result would, no doubt, be in itself a gain in the interests of real knowledge;

but, it may be asked, as it often is in other cases where the iconoclast is at work, what is offered in place of that which is taken away? Is there any other explanation of veins possible? The facts set forth in the fifth part of this investigation, it is submitted, suggest—nay, compel—the adoption of another explanation, which will now be given.

It has been seen that when fragments of Skiddaw slate, from the interior of a vein, are submitted in transparent slices to the microscope, the slate in places seems to have been altered to quartz.

It has also been shown by chemical analysis that the proportion of silica in the walls of veins increases as the veins are approached.

The analyses given in the introduction show that all the rocks in which the veins occur contain a large proportion of silica—from about 57 per cent. in Skiddaw slate to 73 per cent. in Eskdale granite.

It has further been seen that the veins are mostly, if not always, coincident with one or other of the different sets of jointing by which the rocks are intersected. Some of these joints are very much stronger and more persistent than others, and, probably, for reasons which will hereafter appear, those along which the veins have been formed were stronger still. Some of them might actually be lines of faulting, for no doubt great numbers of faults would be formed at the time the district was undergoing those great volcanic and Plutonic disturbances referred to in the introduction, and what more likely than that these faults should coincide with the joints then existing, for they would undoubtedly be the lines of least resistance.

Bischof, in his "Chemical and Physical Geology," vol. iii., p. 122, after giving the analysis of a clay slate from Morgan Rothe Mine, Siegen, states that "by hot sulphuric acid all the bases were extracted from the slate."

It would thus appear that there is a very simple and natural way of accounting for the quartz which forms the bulk of the veins of this district, without assuming, what is opposed to all experience, that long, deep, and narrow fissures at one time traversed the rocks in all directions.

Sulphuric acid is one of the commonest of volcanic emanations, and, therefore, in all probability, was abundant in the Lake District during the disturbed times previously spoken of, so that it is only necessary to assume that solutions of this acid found their way upward along lines of faulting, or along some of the more powerful joints, and there are present all the conditions required to produce the complicated network of veinstone which forms the basis of most of the mineral veins of this district. The acid solution would rob the rocks adjoining the joints or faults of their alkalies and alumina, &c., and the liberated silica would be re-deposited as quartz. One of the first consequences of that operation would be the appearance in the quartz of cavities, equal in volume to that of the materials removed by the acid solution. The magnitude of those cavities, in the aggregate, may be approximately estimated as follows:—

Quartz Veinstone.

Composition.	Relative Weight.	Relative Volume.
Silica	64·56	67·66
Alumina	22·72	
Alkalies, &c.	9·98	32·34
Water	2·74	
	100·00	100·00

It thus appears that the cells would be about 32 per cent. of the total space occupied by the quartz. These cells would, in all probability, be distributed through the vein-

stone, just as they are in the cellular quartz sometimes met with in veins at the present day.

Hitherto reference has only been made to the formation of quartz veinstone, but the carbonate of lime, which however only occurs in very small quantities, comparatively, could be derived from the same source, as will be apparent from an inspection of the analyses—but the lime of the original rock being soluble in the acid solution it would require the presence of some salt, such as carbonate of soda, to precipitate it. At such times as those in which the veins were formed this salt would probably be plentiful.

The formation of veins being thus accomplished, the manner in which the metallic minerals were subsequently deposited in them remains for consideration hereafter. In the meantime, it may be advisable to see how far the results to be expected from such a mode of formation as that suggested are in agreement with the actual appearances presented by veins.

It is submitted that the proposed explanation renders completely intelligible the facts referred to below :—

1. The intimate relation between the mineral character of the country rock and that of the principal parts of the contents of veins. It has been suggested by Mr. J. G. Goodchild,* in a paper on the minerals occurring in Cumberland and Westmoreland that the siliceous character of the veinstones of the Lake District depends upon the time at which they originated, but on the view set forth above it would appear that the composition of the enclosing rock is the chief determining factor.

2. The interlacing of the country rock with quartz, as shown in Figs. 10, 13, and 20, would result from the action of the acid solution along lines of intersecting joints. The

* Transactions of the Cumberland Association for the Advancement o Literature and Science. Part VII. 1881-82.

curious form of the quartz in Fig. 12 may also be easily accounted for in a somewhat similar way.

3. The unbroken or undisturbed condition of the vein-walls is a necessary consequence of the fact that they have never been left unsupported, whilst their indistinctness in some cases is only what might have been expected from the nature of the action producing the veinstone.

4. The occurrence of "horses," as shown in Fig. 26, is quite intelligible if it be supposed that there originally existed a strong joint on each side of them along which the acid solution operated.

5. Loughs, which are usually looked upon as part of the primary fissures that have not been filled, are, on this view, a consequence of the removal of material which originally existed in association with some of the quartz at present in the vein. Probably they have been produced since the metallic minerals were deposited.

6. The evidence of pre-existing faults on the lines of veins would by the suggested action be destroyed, which would account for the absence of such evidence now. The clay partings or "douk" sometimes met with, as previously mentioned, may be the result of a small movement which has taken place since the formation of the veinstone, or it may be that the "douk," which occupies so much of the unproductive parts of veins, existed before the veinstone, and, owing to its impervious nature, prevented the circulation of acid solutions in those parts of veins where it occurs, which would account for the absence of veinstone there.

7. Variations in the breadth of veins would follow as a natural consequence of that variable solubility of different parts of a rock, which is so well known.

In the same way considerable light is thrown upon many other facts which need not now be specially mentioned. It may, however, be interesting to inquire what were the

particular physical conditions under which such chemical changes as are suggested were possible. From a microscopic examination of veinstone—adopting the method of investigation first employed by Sorby—the conclusion is reached that the veinstones of the Lake District were formed under a pressure of at least 30,000 feet of rock. The unreliability and the difficulty of using Sorby's method were perhaps never more clearly established than in this particular instance. From the relation borne by mineral veins to the stratification and cleavage of the rocks in which they occur—many of them, and the oldest, being coincident with the cleavage—it is quite certain that those veins were not formed before the Devonian era. At that time the Silurians had been very severely dislocated, tilted, and denuded, and had, approximately, assumed their present stratigraphical relations, as is shown by the fact that every member of them is, at some point or other, overlain by Carboniferous rocks. It is therefore impossible that the veins were ever covered by the thickness of rock mentioned above. It may be said, of course, that the veins were not formed until after the Permian era, when both the Carboniferous and Permian rocks were spread out over the Lake District. But it is most improbable that these rocks ever did cover the Lake District. One very curious and unrecorded fact may be mentioned as bearing on this point. At the Crossfield iron mines, near Cleator, in the bed of shale separating the fourth and fifth limestones of the carboniferous limestone, a perfectly rounded boulder of Ennerdale syenitic-granite was met with.* It was about the size of a duck's egg, but less elongated, and exactly the same in every respect as boulders of the same kind of rock that can now be found on the sea beach at St. Bees. This fact

* This boulder is in the possession of the author, and was given to him by Mr. J. M. Main, the manager of the Crossfield mines.

shows that at the time the lower beds of the Carboniferous limestone were forming the Ennerdale syenitic-granite was above the sea. Whether it so remained throughout the carboniferous period has not yet been ascertained, but it is very probable that it did, for in the breccia forming the base of the permians in this district fragments of lavas and ashes and of Ennerdale syenitic-granite are very abundant.* No doubt a considerable amount of denudation took place between the close of the Carboniferous era and the deposition of the breccia, but that is really immaterial to the argument, for if any part of the Carboniferous rocks ever did overlay the Ennerdale syenitic-granite it had clearly been removed before the permian breccia was formed. The most that can be said, therefore, is that a few hundred feet of upper permian rock (St. Bees sandstone) *may* have covered the Lake District, but that is most improbable, although there are not any facts known which will *directly* disprove it.

It is more than likely that the mineral veins were formed during one or other, or perhaps in part during each, of the periods of disturbance which have left so many marks upon the district. One of these periods, as previously mentioned, intervened between Silurian and Carboniferous times; another ushered in the Permian era, whilst one series of movements, if not more, of a somewhat violent character took place in Mesozoic or Neozoic times. Now the amount of denudation to which the Silurians have been

* Since this was written, Archibald Geikie, F.R.S., Director General of the Geological Survey, in a lecture delivered at the Royal Institution, February 5th, 1884, "On the Origin of the Scenery of the British Islands," has said,—"The carboniferous limestone on the flanks of the Lake District is so thick that it must have spread nearly or entirely over the site of the mountains. But it was overlaid by the millstone grit and coal measures, so that the whole area was probably buried under several thousand feet of carboniferous strata."—*Nature*, p. 347, vol. 29.

subjected since Devonian times—the furthest back that the formation of these veins can be placed—probably does not, in some parts of the district at any rate, exceed 3000 or 4000 feet, so that the thickness of rock overlaying some of the veins, at the time they were formed, cannot have been greater than that.

The next matter to be considered is the introduction of the metallic minerals into the veins. Whatever may be the age of the veinstones the metallic minerals must be younger, but how much younger it is impossible to say. It has been seen that the cavities in the cellular veinstone would, in the first instance, amount to about 32 per cent. of the total volume of the quartz. It has also been seen that the metallic minerals do not occupy, in any case, more than 20 per cent. of the bulk of the veinstone, so that there would be abundance of room for those minerals in the quartz cavities, and there would be sufficient space beside for the accommodation of the non-metallic minerals, such as barite, that were formed after most of the metallic minerals, as well as for the large quantity of quartz, in crystals, which has found its way into the vein at various times since the first introduction of the metallic minerals.

In this way it is submitted all the complicated appearances met with in veinstone veins may be explained. Of course it is not to be supposed that the cavities left in the veinstone after its separation from the bases associated with it in the original rock were all of one size and form. Some of them might be long, deep, and narrow, so that, when filled, they would form "ribs" of ore; others might have the form and dimensions of "bunches" of ore, but the bulk would most likely be such as, when filled, would give rise to the "spots" and "blotches" so common in veins.

The next question that arises is, where was the source of the metallic minerals? All those which occur in the largest

quantities in veins are sulphides. They are the following:—

1. Chalcopyrite = $Cu\,S + Fe_2\,S_3$
2. Galena = $Pb\,S$
3. Blende = $Zn\,S$
4. Pyrite = $Fe\,S_2$

The other minerals are much less abundant, and some of them are very rare. A few are sulphides, but they are mostly silicates, oxides, or carbonates, and are probably only alteration-products from the above mentioned sulphides, so that it is only necessary to ascertain the source of the latter.

Now the source of sulphur combinations, such as the above, so far as all experience goes, is volcanic, and seeing that this district has, on several occasions, been the scene of extraordinary volcanic activity, it is nothing more than might have been expected that metallic sulphides, and even non-metallic sulphates, such as barite, should have been produced during those disturbed times, and that they should have been deposited in the rocks if there had been a suitable receptacle for them; and, surely, there could not have been anything better adapted for such a purpose than the cellular quartz of the veinstone as it was originally formed.

The only difficulty now to be overcome is as to how the sulphides were produced? Were they condensed from sublimed vapours, or precipitated from aqueous solutions, as it is quite clear from the nature of the veinstones that they could not have been injected as igneous-fluids? When sulphides of iron, zinc, lead, and copper are heated in the presence of air, oxygen, or steam they are decomposed, therefore if pyrite, galena, chalcopyrite, and blende resulted from the condensation of vapours, it will be necessary to assume that the exact combining proportions of the sulphur and metals were present in every cavity of the cellular quartz, which is next to impossible, because the condensation would not be a simple condensation of sulphides

that had just been vapourized, but the production of a definite combination from an indefinite mixture of elementary substances that in all probability had previously existed quite apart. It seems, therefore, more likely that the ores were precipitated from aqueous solutions in the way indicated below for blende, although the reaction necessary for the production of each ore might be different :—

Solution.	Precipitant.	Precipitate.
$Zn\ H_2\ SO_5$	$K_2\ S$ or $Na_2\ S$	$Zn\ SH_2\ O$

At ordinary temperatures the resulting zinc sulphide would be hydrated as shown above, but it is probable that at such higher temperatures as accompanied these reactions, under pressure, the precipitate would be anhydrous, as is known, for example, to be the case with hematite.

$K_2\ S$ or $Na_2\ S$ would result from the action of sulphuric acid on the alkalies in the country rock.

It is only necessary for one metallic solution to have been present in the vein at once, because it has been seen that the different ores were not all deposited together but in succession. This, also, partly explains why it is that some minerals are more abundant in veins having certain directions than in those with other courses. Take chalcopyrite for example. This ore is most frequently and most abundantly found in veins having an easterly and westerly bearing. It also appears that it was the earliest of the metallic minerals to be introduced into veins, and this may be the reason that it is so much more abundant in east and west veins than in those which may be roughly spoken of as north and south veins—for the east and west veins seem to have existed first. This may not be so in every case, but it is in a large proportion of them, and notably so at Goldscope, where the east and west copper vein has been shifted by the north and south lead vein. Facts of similar import may be observed in adjoining areas, such as the Whitehaven hematite district.

There, owing to great lithological variations in the strata, the existence of faults and their relative ages are easily ascertained, and it is a well established fact that the east and west faults are older than those which are nearly north and south.

The banded structure so common in the veins of other districts is not met with here, but the phenomena exhibited by such veins may be quite easily explained with the help of the foregoing considerations, without assuming that they were preceded by fissures or that the banded appearance of their contents is due to the repeated opening of such fissures. Suppose a narrow vein of quartz had been formed in the way herein suggested, and that the pores or cells in it had been filled by some metallic mineral, say chalcopyrite. Suppose, further, that at some subsequent period the first part of this process were repeated, and that the acid solution acted on both walls of the vein already in existence. The consequence of that operation would be the formation of two additional ribs of quartz veinstone, one on each side of that containing the chalcopyrite. The pores in these two later formed ribs might eventually be filled with galena—and so, by repeating the process, two deposits of blende might be got outside the galena. Thus it becomes possible to account for the banded structure of veins without the assumption of fissures, and thus is avoided the great difficulty there would be under such circumstances in keeping the walls apart whilst the vein materials were deposited. The quartz ribs formed after the first one might only be single, that is, merely on one side of the already existing vein, so that then the bands would not appear in pairs, but singly, as they are often known to do.

An explanation having now been attempted of the most important facts presented by veins with veinstones, attention will next be directed to those veins without veinstones.

All the arguments that have been employed in the foregoing discussion for the purpose of exhibiting the incompetence of the old fissure idea to explain the facts of veins with veinstones are equally forcible now. If so, it is clear that the ores in this class of vein must be the result of substitution or replacement, for they could not possibly have been derived from the original rock, like the quartz of the veinstones.

As elsewhere suggested,* this substitution was probably effected indirectly, the place of the original rock being first taken by dolomite, which was subsequently removed and replaced, for example, by hematite. Veins of dolomite are by no means uncommon in the ash rocks of Eskdale, and they present all the features of hematite veins, the "horses," the "loughs," and the same semi-stratified appearance. These veins probably originated in some way not unlike the following:—Heated water containing carbonate of soda, rising along the more open joints, would attack the siliceous and aluminous rocks through which it passed and carry the more easily dissolved portions of them away in solution. At the same time a part of the soda might react on the salts of lime and magnesia usually met with in underground waters, and form a precipitate of carbonate of lime and magnesia in the space previously occupied by the rock dissolved from the sides of the joints.

From the manner in which the dolomite of these veins is traversed by strings of hematite, as exhibited in Fig. 24, it shows clearly that the former mineral existed first. If, therefore, it be assumed that all hematite veins were once veins of dolomite, their replacement may have been effected in some such way as the following:—It is well known that perchloride of iron is a common volcanic product, and if it

* "Hematite Deposits of West Cumberland." N. of E. Inst. of Mining and Mechanical Engineers. Part I. Vol. 30.

be assumed that during some period of volcanic activity a solution of this salt was forced up some of the fractures or more open joints in the rocks, and so brought into contact with the dolomite veins, a chemical reaction would ensue which would bring about the following results:—The dolomite would be carried off in solution and hematite would be thrown down in its place, so that the walls would never be left unsupported, and, therefore, would not have any tendency to fall away. The reactions indicated have already been explained elsewhere.*

The age of the hematite veins is probably early Permian. This is shown by two facts. First, rounded and smoothed pieces of hematite have been met with in the breccia which terminates the Lower Permian in West Cumberland. Secondly, a bed of hematite occurs in the Upper Coal measures at Millyeat, about five miles from Whitehaven.

Finally, the principal conclusions arrived at in the argumentative part of this investigation may be summarised as follows:—

1. Veins are not filled fissures.
2. The variations in breadth are not due to the sliding of the walls upon one another, but to variations in the solubility of the rock.
3. Veinstone is part of the rock which originally existed where the veins now are, and is a result of metamorphism.
4. The metallic minerals, hematite excepted, were deposited in cavities of the veinstone from chemical solutions.
5. Hematite veins are substitutional deposits.

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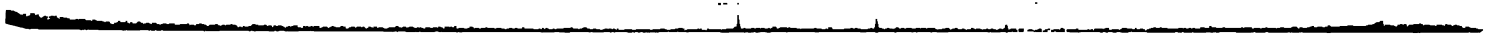
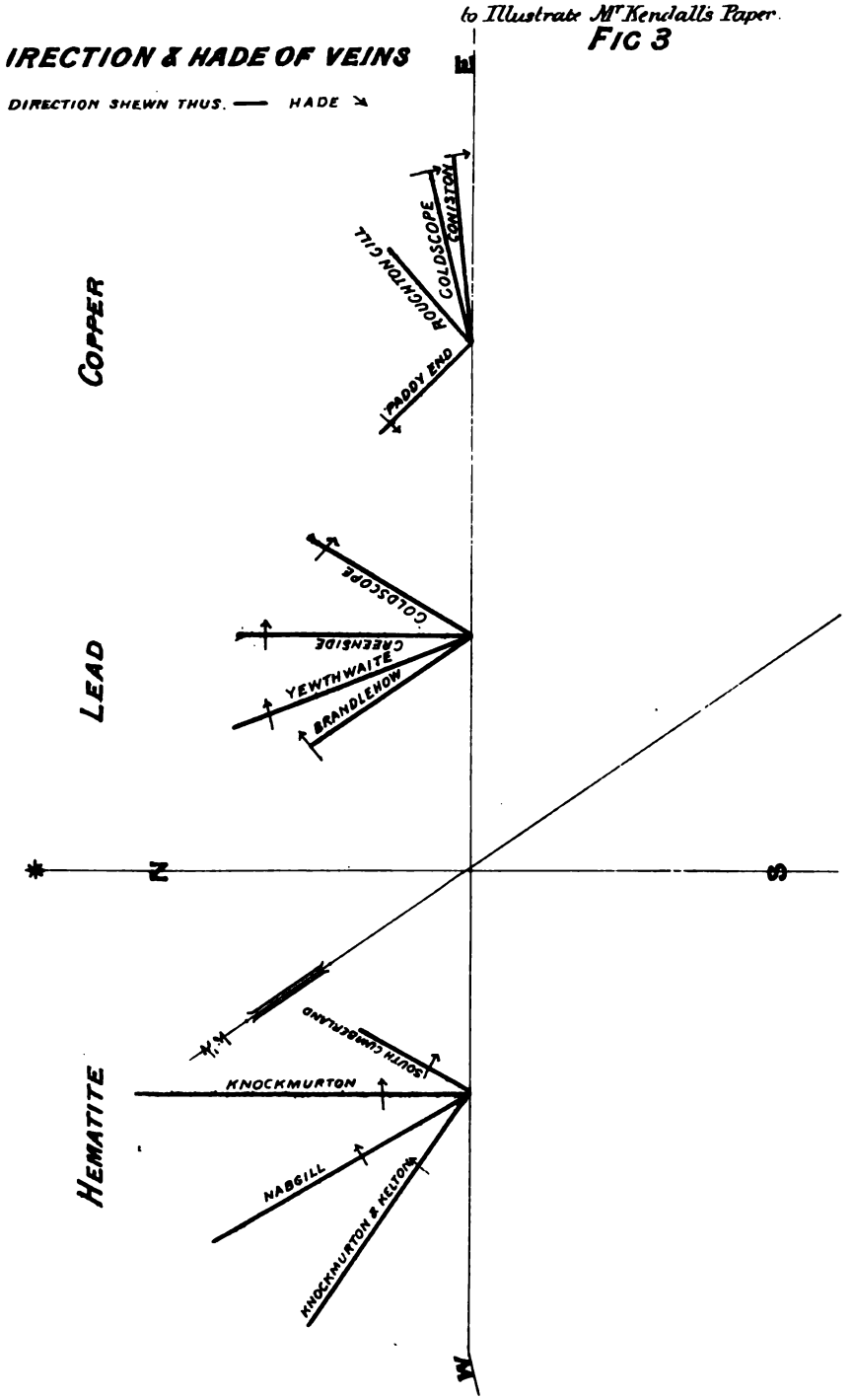
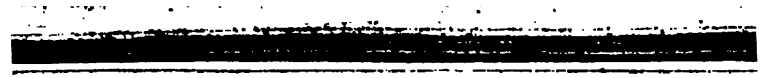
* "Hematite Deposits of West Cumberland." N. of E. Inst. of Mining and Mechanical Engineers. Part III., Vol. 28; and Part V., Vol. 31.



Trans. Man. Geo Soc. Part XVI Vol XVII.
to Illustrate Mr Kendall's Paper.

FIG 3





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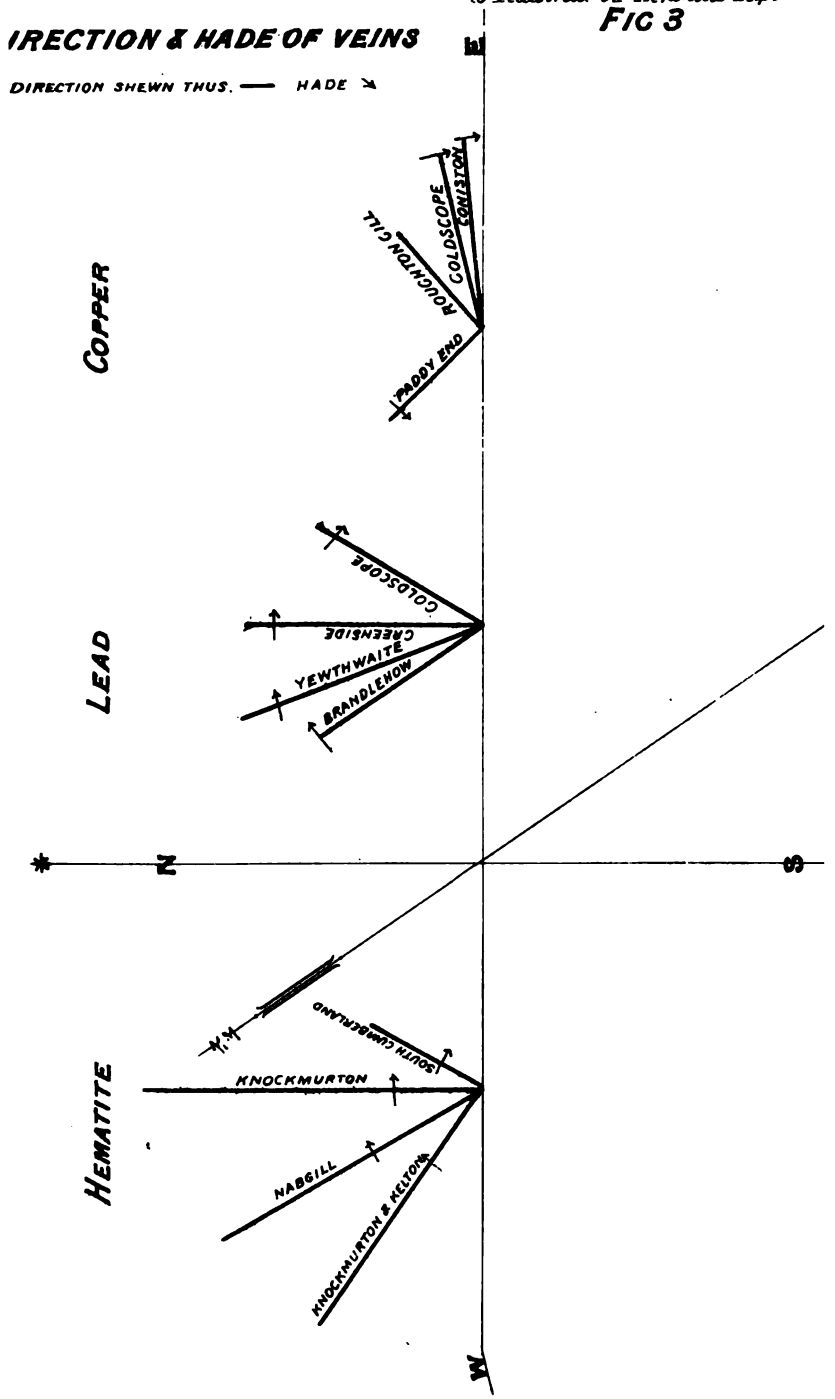
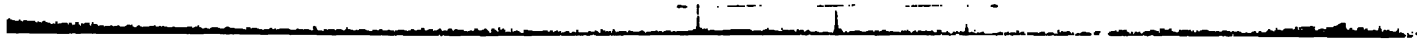
to Illustrate Mr Kendall's Paper.

FIG 3





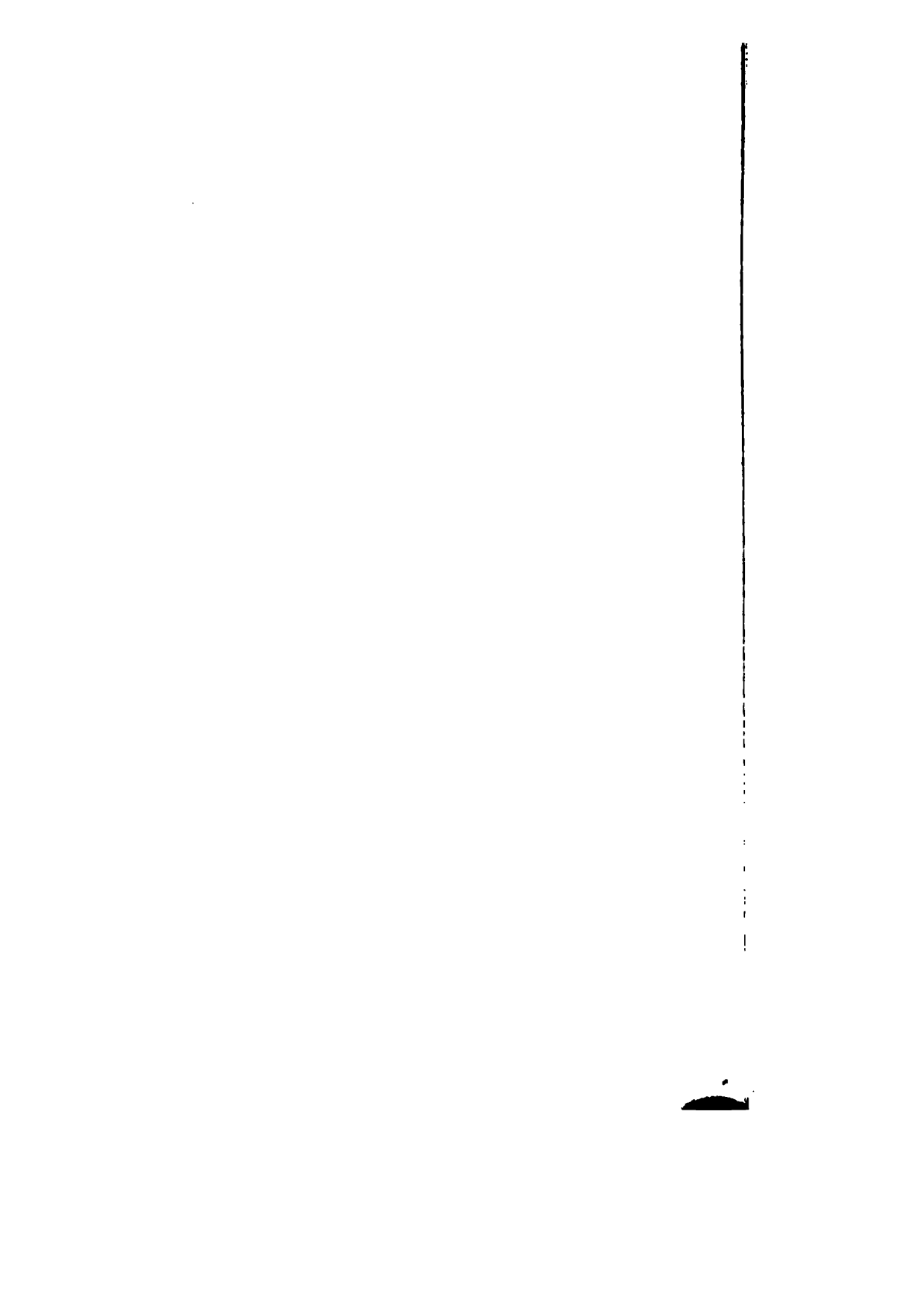


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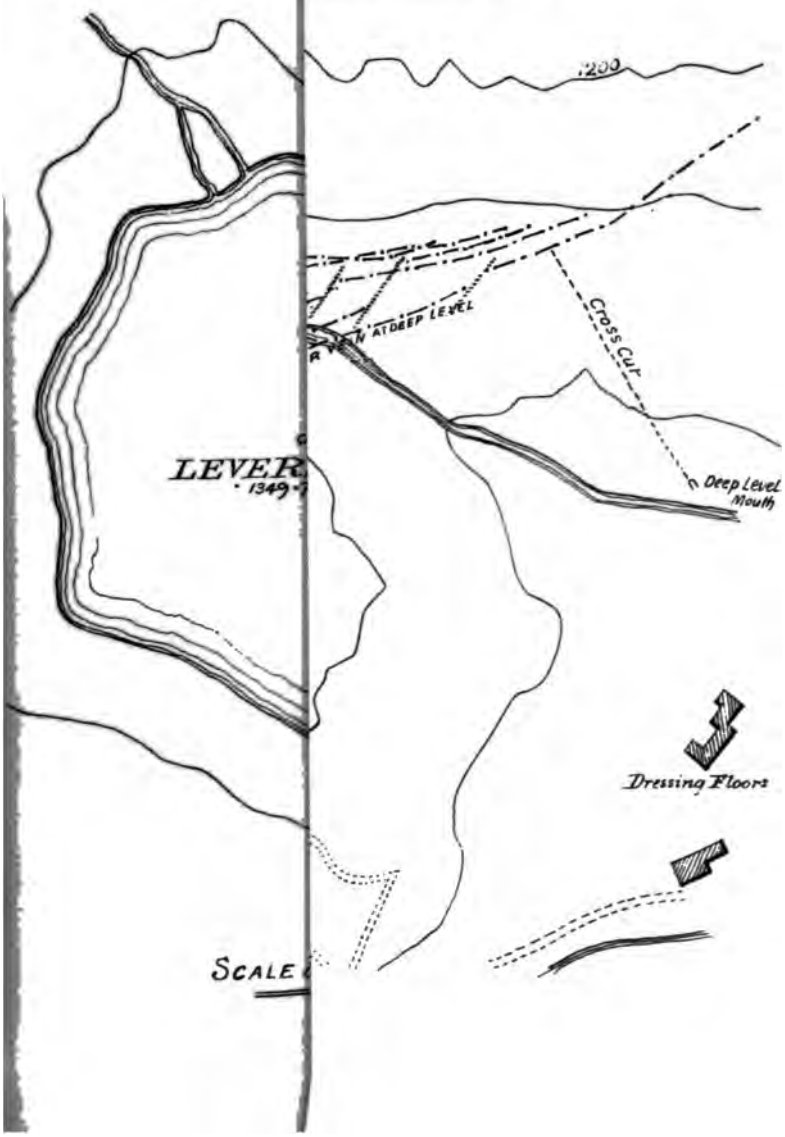
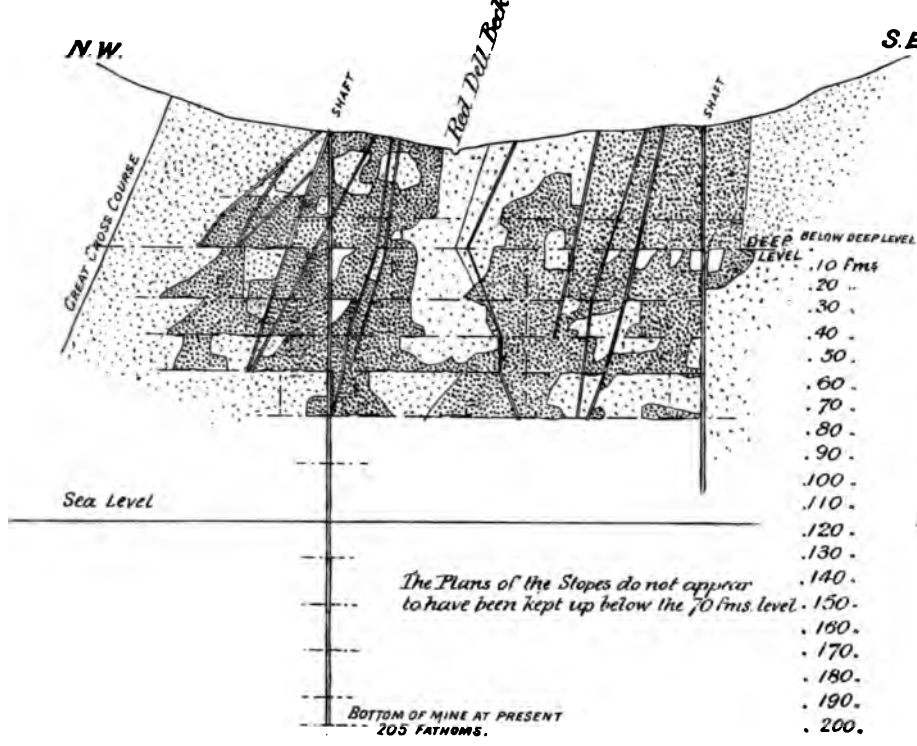
PLATE 6.

TON MINES.

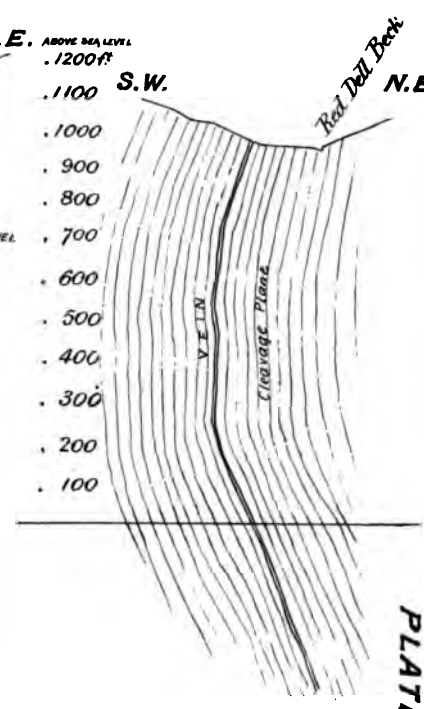


Bonser Vein

LONGITUDINAL SECTION.



TRANSVERSE SECTION



SCALE 80 FATHOMS TO AN INCH.

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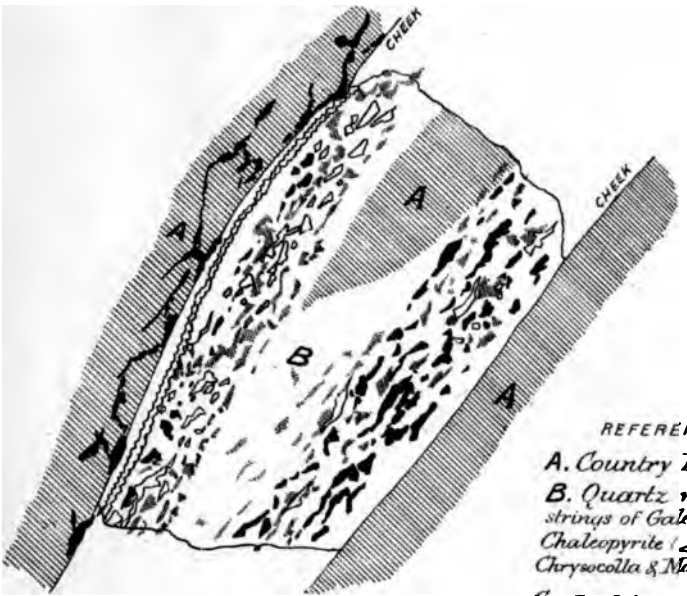
PLATE 7.

FIG. 9



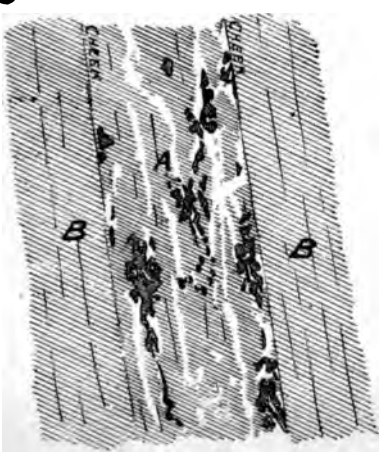
REFERENCE

A. Country Rock

B. Quartz with spots & strings of Galena ( ) Chalcopyrite ( ) and Chrysocolla & Malachite ( )

Scale, 2½ feet to an Inch.

FIG. 10



REFERENCE

A. Vein consisting of Strings of Quartz through the Rock - The dark markings represent the Ore (Chalcopyrite), the unshaded part, the Quartz

B. Country Rock

Scale, 4 Feet to an Inch.

FIG. II

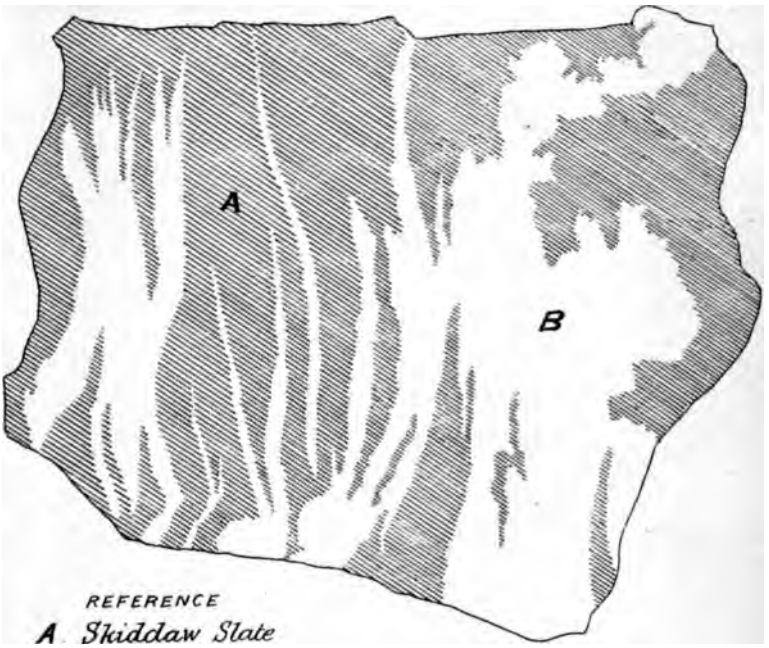
REFERENCE

A Ash Rock
B Quartz
C Chalcopyrite

Scale. Full Size.

To Illustrate Mr Kendall's Paper.

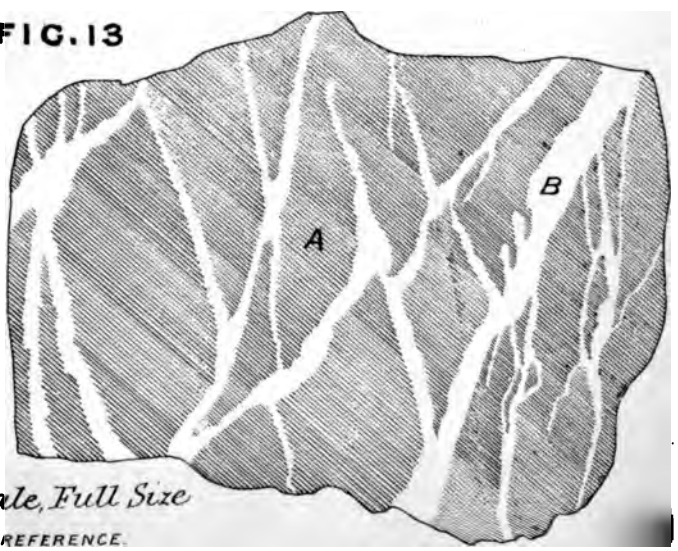
FIG. 12



REFERENCE
A. Skiddaw Slate
B. Quartz

Scale, Full Size.

FIG. 13



Scale, Full Size

REFERENCE.
A Skiddaw Slate
B. Quartz

FIG. 14

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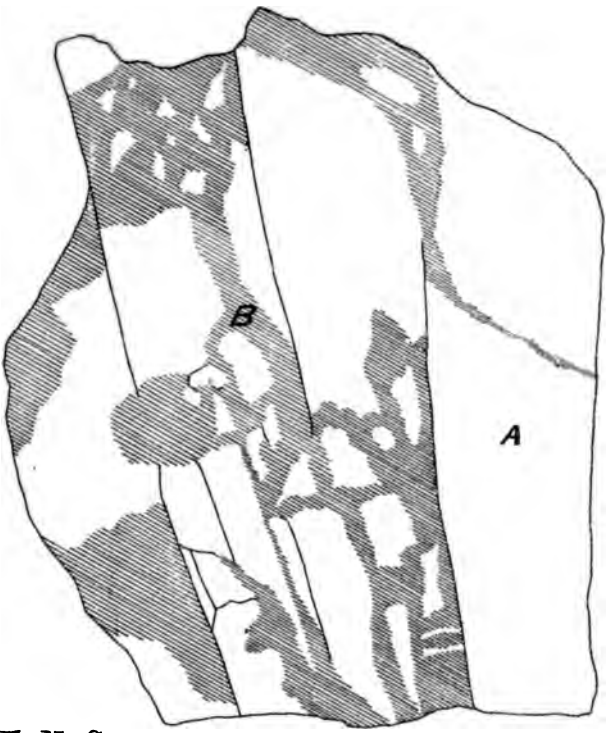
to Illustrate Mr Kendall's Pap



Scale. Full Size.

REFERENCE

A Skiddaw Slate B. Bitter S

FIG. 15

REFERENCE

A Quartz
B Galena

Scale. Full Size

FIG. 16

REFERENCE.

A Quartz C Chalcopyrite
B Galena D Malachite
(In Loughs)

Scale. Full Size.

FIG. 17

Scale, Full Size.

FIG. 18

REFERENCE

A Skiddaw Slate
B Galena
C Gossan

REFERENCE

Eskdale Gra
Bitter Spar
Hematite

Scale. Full S

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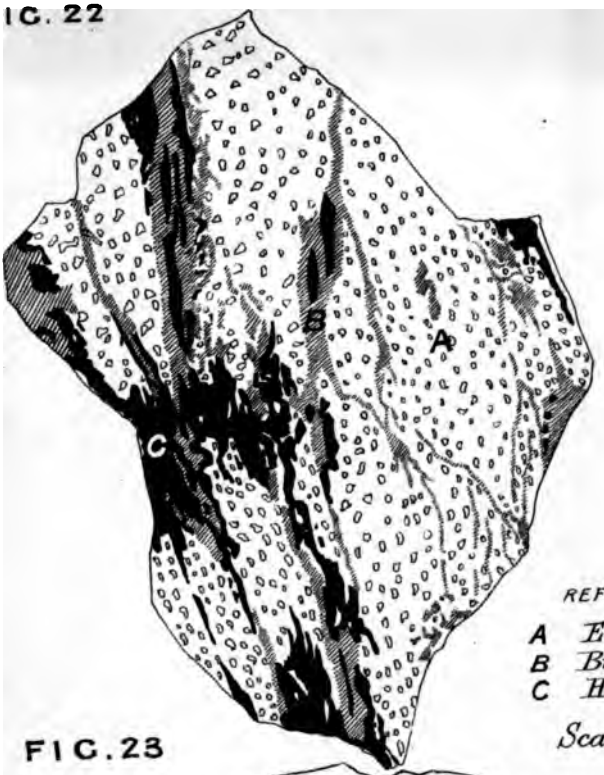
to Illustrate Mr Kendalls Paper

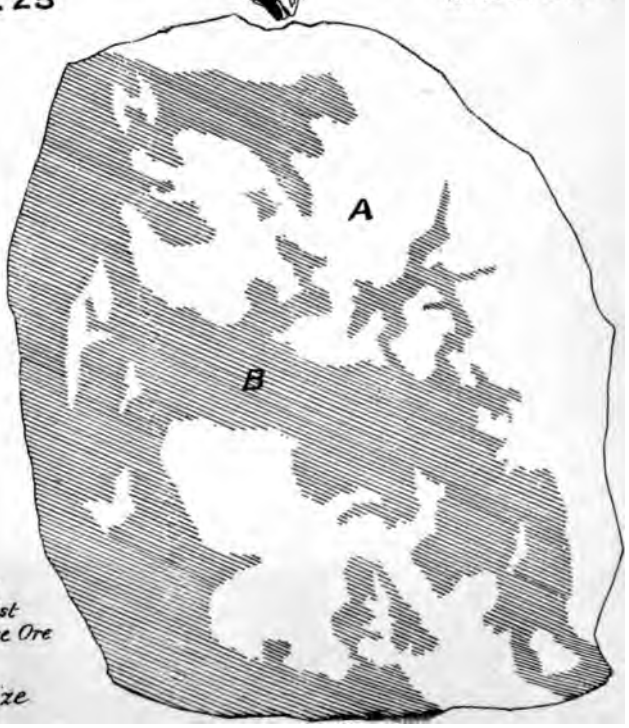
FIG. 22



REFERENCE
A Eskdale Granite
B Bitter Spar
C Hematite

Scale Full Size

FIG. 23



REFERENCE
A Mica Schist
B Manganese Ore

Scale ½ Size

to Illustrate Mr Kendall's Paper

FIG. 24

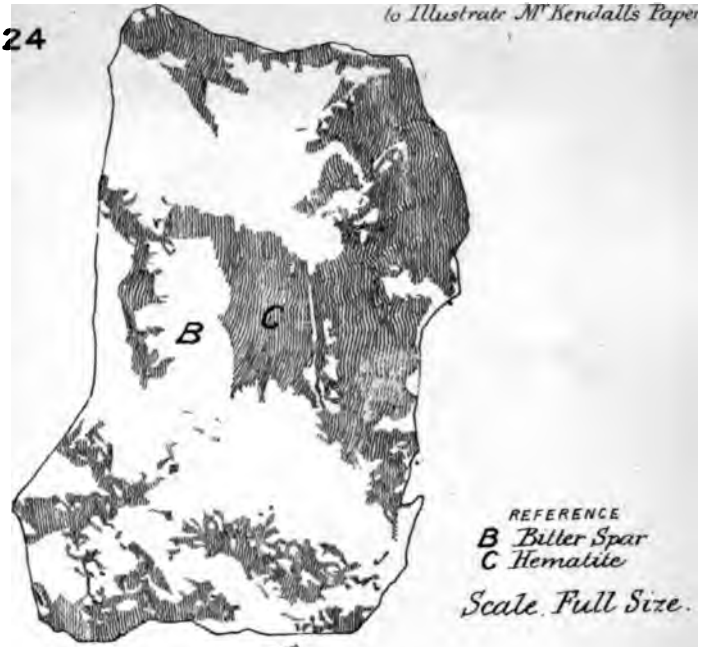
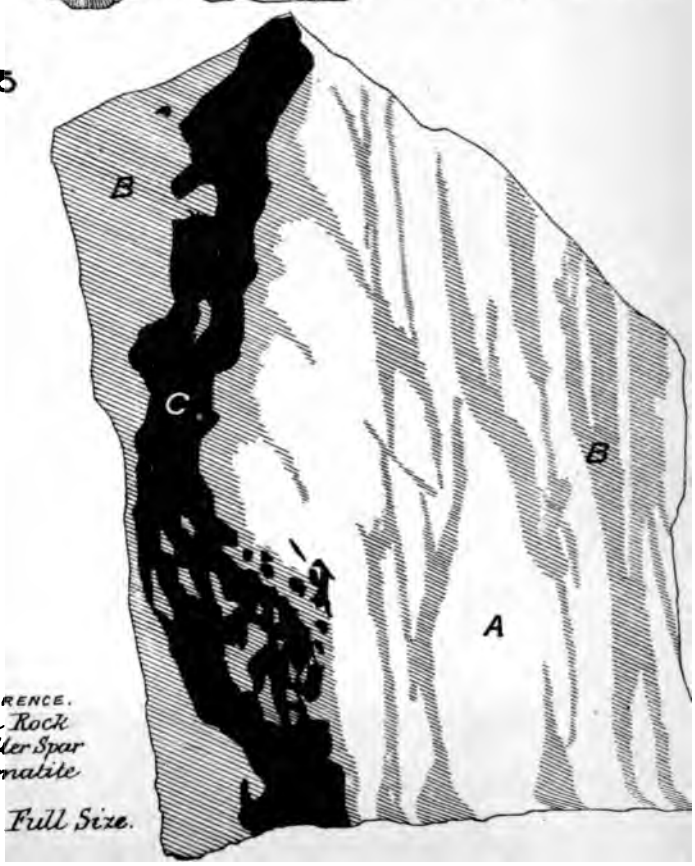


FIG. 25



TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XVII. SESSION 1883-84.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 6th day of May, 1884, in the Literary and Philosophical Society's Rooms, George Street, Manchester.

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

Mr. M. E. JOHNSON, Rainhill, Prescot, Mining Engineer, was balloted for and unanimously elected an ordinary member of the Society.

The HONORARY SECRETARY (Mr. Martin) stated that he had received a letter from Mrs. Forbes, acknowledging and thanking the Society for the resolution of condolence upon the death of her husband, Mr. J. E. Forbes, which was passed at the last meeting of the Society. He also announced that the Society had lost two members by death since the last meeting, namely: the DUKE OF BUCCLEUCH (who had been a life member since 1872), and Mr. JOHN LANCASTER, a large colliery owner, and formerly M.P. for Wigan, who had been a member since 1858.

PATENT SAFETY CATCHES.

Mr. Brown exhibited the model of a Patent Safety Catch, applicable to cages where wire rope guides are used; and, in answer to questions, explained the mode of working. In addition to a small working-model there was exhibited the full-sized apparatus, which, Mr. Brown said, had been tested at the Atherton Collieries with a load of 25 cwt., and a drop of 6 or 7 feet, there was calculated to have been a strain of something like four tons on one rope alone. After coming through the clamps it did not descend half an inch.

The Chairman (Mr. Dickinson) said that, up to the present, they had not had safety catches applied to wire rope guides—only to the wooden conductors—and there were nearly 200 places, in this district, where such catches were applied to the wooden conductors. There was not, to his knowledge, a single catch of anybody's invention, applied to the wire rope guides. Mr. Brown had stated that in testing his apparatus at the Atherton Collieries, when disconnected, it dropped only half an inch before stopping. He would like to ask Mr. Brown if the guides in use were the ordinary wire rope guides, when that great strain came on?

Mr. Brown: The weight we had on was 25 cwt., that was on one corner—on one single rod—and the cage was let down as quickly as possible.

The Chairman: Would there be no risk of such a sudden jerk, thrown upon the wire conductors, breaking them, or drawing a wire rope conductor through the clamps at the top? Only last year we had a fatal accident in this district through a wire rope guide slipping through the clamp without any weight but its own; therefore, unless the ropes

and the fastenings are strong enough to bear such a jerk, there might be really more danger than advantage in it.

Mr. BROWN: They can surely make the clamps strong enough to bear the strain, just as those of the winding rope have to be made strong enough.

Mr. RIGBY: The head-gear should also be very strong.

A Member asked if the action of the apparatus was instantaneous, or whether there was any "slide" in it?

Mr. BROWN: There is no slide whatever; it is held almost before the rope breaks. The quicker they go, the easier it gets hold.

The CHAIRMAN: The ropes and couplings do not always break when the cage is going up. They sometimes break when it is going down. There was an instance of the kind in this district, when six lives were lost.

Mr. BURROWS said the experiments made with the apparatus at Atherton were satisfactory. It stuck very fairly when the machine was in order. Once or twice it missed, but that they could trace to some defect in the apparatus. But supposing the rope broke near the drum, at the top, before the catch could come into play? The rope had to go quicker than the cage, so that the lever could lift it. So long as the rope was tight it could not work. The difficulty he had was to know what should make the rope overtake the cage sufficiently to enable the lever to come into play.

Mr. JOHN KNOWLES said that at one of their pits, some years ago, wire rope conductors, and also iron rod conductors, were tried. In that case the teeth of the catch were sharpened, to enable them to grip the wire rope or rod; but they were afraid if this was continued it would tend to break the rope in two. Their feeling was against the idea of throwing an immense pressure, if anything broke in descending, because the wire rope conductors did not possess

the stability requisite for standing the concussion which would arise from a sudden breakage. It was, however, very proper to bring forward a model of this kind, as it showed that there were means of dealing with a difficult subject. The only question was one of strengthening the conductors.

Mr. MARTIN read the following letter which he had received from Mr. G. C. Greenwell :—

"Duffield, near Derby,
"May 2nd, 1884.

"To the Honorary Secretaries of the
"Manchester Geological Society.

"Dear Sirs.

"After reading the paper read by Mr. Hall on March 7th to your Society, I am induced to draw attention to the paper which I read to the meeting of May 31st, 1870. I enclose a copy, and will be very much obliged if you will, at the meeting on May 6th, read over that part which I have scored, pp. 7, 8, 9.

"I remain, Dear Sirs,
"Yours very truly,
"G. C. GREENWELL."

ELECTRIC CURRENT DOWN RIVIN (PIT) COLLIERY.

BY JOHN KNOWLES, M.Inst.C.E.

During a thunderstorm on February 21st, 1884, a distinct shock was felt in the workings at the New Rivin Pit, Little Lever.

The Colliery is situated close to Hall Lane, the main road between Moses Gate and Radcliffe, and about three miles

from Bolton; the Upcast Pit being about 30 yards from the road and the Downcast 50 yards.

The Upcast Pit is 9 feet in diameter inside the brickwork, which rises as a chimney, about 24 feet above the ground: in this pit there is no winding, but there is one pulley, 5 feet in diameter, which stands without rope, to be used with a portable capstan engine in case of emergency; there are also two folding iron doors, which take up a space in the chimney 8 feet high by 5 feet wide. The pit is 97 yards deep.

The Downcast Pit is also 9 feet in diameter and 97 yards deep, with a sump of 14 yards further: in the pit are four iron wire guides 1¼ inch in diameter, and two iron wire ropes between the cages; the former go into the water in the sump, and the latter terminate just below the landing plates. There are also a bell-wire of galvanised iron and 3-inch steam pipes, which are mostly uncovered. The two cages are made of iron, a steel rope being used for one cage and an iron one for the other. This pit is surrounded with the ordinary cast plates and rails, but there is not any connection with the chimney of the Upcast Pit.

There are the usual buildings about the pits, viz., engine-house, boilers, and cabins; also a chimney 6 feet square and 20 yards high, but no lightning conductor on it.

At the bottom of the Downcast Pit there are the usual plates and rails, with the steam pipes extending to the two engines on the east side and one on the west. Those going eastward are laid up a brow with a gradient of 1 in 3 to the Lower Three Yards Mine, and then a short distance on a level to the first engine, which winds up the down-brow in this mine. At this point there is a rise tunnel to the Lower Yard Mine, worked as a self-acting incline. The steam pipes are carried to the top of this tunnel, and then on a short level to the engine at the top of a down-brow in

the Yard coal, where a wire rope is used to wind the coal to this point. There is also a wire rope used in this brow to work a small pump which forces water to the top of the incline, whence it runs to the pit.

On the west side the steam pipes are laid on a level in the Lower Yard Mine to a small engine, which winds coal up a dip tunnel from the Lower Three Yards Mine. This engine has a 6in. cylinder with 10in. stroke, the dip tunnel being 48 yards long with a gradient of 1 in 5.

The electric current appears to have struck the chimney at the top of the Upcast Pit about 2-30 p.m. on the day named. It displaced a large quantity of brickwork, and then came down outside the chimney, striking the ground close to it and making a large hole. It then went along the ground to the cast plates at the top of the Downcast Pit, and, it is presumed, went down the steam pipes, and so into the workings—on the east side going through the yard down-brow engine and along the rope to the waggons, at which Edward Ramsden and James Kirkman stood; and on the west side passing along the pipes to the engine, where Mr. James Seddon, the manager, was.

The strength of the current must have been very great as experienced by W. T. Whitehead, a waggoner, who was seated four or five yards from the bottom of the Downcast Pit. He says he saw a brilliant flash and heard a great noise, which sounded as if in the pit. He had the heel of his clog on one of the plates at the time, and felt a tingling sensation in his leg, which lasted a day or two; the soles of his clog was burnt as if a hot iron had been drawn over it. When this occurred he at once went to tell the manager, Mr. James Seddon, and when he got to him, although he had left a cold place, he was covered with perspiration and evidently unnerved. Another waggoner, James Hollingshead, was at the pit at the time, and also saw the flash and heard the noise.

Edward Ramsden and James Kirkman were in the Lower Yard Mine down-brow, about 392 yards from the pit, and at the time had their hands on the iron rim of the last of a train of waggons which were attached to the rope. Each expressed to the other that he felt something very queer, and thought he was electrified. Their idea was that the shock was similar to what they had received at the electrifying machine at Bolton fair.

The manager, Mr. James Seddon, was on the west side in the Lower Yard Mine, at the small engine, which had just been erected at the top of the Lower Three Yards Mine dip tunnel, 300 yards from the pit, and at the time was winding up the second waggon. He had his hand on the steam handle, and felt a shock which numbed him for a few seconds, so that he could not see or move, and afterwards caused him to give way, and bend in his walk with much pain. In about half an hour he came out of the pit, and on arriving at the surface ascertained what had occurred. He was still capable of going about, and went to the chief office some short distance away, about 4-30, when he began to feel more the effects of the shock. He then went home, and was quite prostrated, so that he had to go to bed. This prostration continued for six days before he was able to get up and walk. Since then he has gradually improved, but feels the effects of the shock if he gets cold or his feet wet. His hearing and speech have not been affected, but the sense of smell has almost left him, and he has not been able to sleep at night.

From the foregoing statement it appears that there must have been a very strong current of electricity passing down the iron work of the pit, and it is fortunate that much of it was distributed before it reached the workmen in contact with any metal. The manager, being the nearest in direct contact, appears to have suffered the most, as the waggoner

at the bottom of the pit was only connected with the plates by a wooden clog, and the two others, at the bottom of the Lower Yard coal incline, only received a shock after it had passed many means of distribution.

Two other cases of a similar kind to this have occurred—one at the Fairfield Moor Colliery, on the 12th of July, 1880, on which a paper was read before the members of the North of England Institute of Mining and Mechanical Engineers, and is recorded in Vol. 30 of their transactions; the other was at West Thornley Colliery, on the 11th December, 1883, and a paper was read before the same Society, and is also recorded in Vol. 33 of their transactions.

The CHAIRMAN said that occurrences such as Mr. Knowles had described were by no means numerous in colliery districts. When this occurred at the New Rivin Colliery he made a personal investigation; and he ascertained, he thought, all the particulars which Mr. Knowles had given them (though, perhaps, he had given them more fully), but there were one or two men who made statements to him (Mr. Dickinson) who were not mentioned by Mr. Knowles. For instance, a banks-man, Mark Howcroft, said that he was in the cabin, sheltering from the storm, between two and three o'clock in the afternoon, when a vivid flash of lightning came; and on leaving the cabin, he found that a portion of the brickwork of the chimney at the top of the up-cast shaft had been blown away towards and beyond the down-cast shaft; that some bricks had gone down the down-cast shaft; and that the thunder followed the lightning very quickly, and frightened him very much. He thought Mr. Knowles stated that there was a steel rope in the down-brow where the two boys received the shock from the train of tubs.

Mr. KNOWLES: An iron rope, I think.

The CHAIRMAN: That rope, I think, was attached to the chain of tubs.

Mr. KNOWLES: Yes.

The CHAIRMAN: There was also an iron signal wire in the brow, which I think was not mentioned.

Mr. KNOWLES: Yes, there was.

The CHAIRMAN: So that there was a communication by the steam pipes from the top of the downcast shaft to the bottom, and also in one direction to where the engine was, and from that engine by means of a pump pipe, a rope and a signal wire to where the boys received the shock at the train of tubs. There was also, in addition to the steam pipe coming in, another pipe going back to the upcast shaft, taking back the discharged steam water. Then in the other direction there was a steam pipe from the bottom of the downcast shaft to the engine, where the manager was struck. The marks it left were only apparent upon the chimney of the upcast. Bricks were blown away from the top of the chimney, and a rent was made down to the top of the iron doors, where a hole was forced through the brick-work.

Mr. KNOWLES: There were no pipes down the upcast.

The CHAIRMAN: But it first struck the upcast. Was it supposed that it descended the downcast?

Mr. KNOWLES: Yes, the downcast. It would then be distributed.

Mr. SEDDON (in reply to the Chairman) said he had his hands upon the handle of the engine when he received the shock. He did not know, until he was told afterwards, that an electric current had descended the pit. After the occurrence he became unconscious for a few seconds, and remarked, afterwards, that he felt a strange sensation. A dataler, who was standing by, said that he looked "rather strange," and asked him what it felt like. He (Mr. Seddon)

replied that it felt like electricity. A short time afterwards some wagoners came along, and remarked that something in the shape of lightning had come down the shaft; but he had no idea at the time that it really was so. He might say, further, that the two men, Ramsden and Kirkham, did not know of anything unusual having taken place until they came out of the pit.

The CHAIRMAN said that some of the men referred to by Mr. Knowles described to him that the shock was something like what they had received from a battery at Belle Vue, or some other place.

Mr. SEDDON said the pit had been visited by a teacher of electricity, whose opinion, after going to the bottom of the up-cast shaft, was that there had been no electric current at that place. He made a very minute investigation with regard to the pipes lying in the various roads; and it so happened that where the pipes were laid was perfectly dry—only the wire rope attached to the wagons, which Ramsden and Kirkman had hold of, was slightly damp —the gentleman he referred to said that the shock might have been felt most strongly in that part. In the workings, where the men felt it, the drum, rails, &c., were all of iron. The rope connected with the wagons being of the same metal, and they were both under the impression, before they heard the true explanation, that something strange had happened.

The CHAIRMAN said he did not think the current passed along the rails; he observed places where they were not in contact; but there was continuous communication through the pipes in both directions.

Mr. J. S. BURROWS observed that during a thunderstorm, in about the years 1879 or 1880, a similar occurrence took place at the Arley Pit, of the Atherton Collieries. When he got to the pit in the afternoon he found all the women who were employed at the screens in a great state of alarm.

On asking what was the matter he was told that the pit had fired. The banksman at the pit seemed dazed. Everyone said that the blaze had gone down the pit, and it took him a long time to persuade them to get to work again. Others down the pit said that the place was lit up, and a taker-off, 100 yards away from the bottom of the shaft, said he could see the light distinctly. It was the report—thunder or something else—which had frightened the women; but no marks could be found showing damage. The wire rope guides were slung to weights which hung in water; so he supposed the current had descended thus and spread itself through the damp earth.

The CHAIRMAN: I think there were no marks left in the Rivin pit.

Mr. SEDDON: None whatever.

Mr. CALVERT: Said his impression was that the current reached the men at the tubs through the wagon rope, and not through any pipes. It had passed to the engine along the steam pipes, and then through the iron drum to the rope; that, at least, was his impression.

The CHAIRMAN: There was no rope to that part of the pit where Seddon felt the shock.

Mr. CALVERT: It certainly passed to him along the steam pipes; from the engine on the east side it passed to the rope.

Mr. KNOWLES said there was no doubt that the current would be strong in going down into the pit, but it had distributed itself amongst the metals that were there; it would get to the plates and strike the wagoner, and then, going along the East side, it would be carried by the steam pipes to the engines.

The CHAIRMAN: Just as an explosion took place at the Risca pit, two years ago, there was a violent thunderstorm going on, and some persons attributed the explosion to a

flash of lightning descending the upcast shaft. But the mine was a fiery one, making a good deal of gas, and I thought the explosion was explainable in other ways. A doctor in the neighbourhood held the view strongly that a flash of lightning had done the whole of the mischief.

Mr. KNOWLES: That is mentioned in the Transactions of the Northern Institute of Mining Engineers.

Mr. STIRRUP asked if it was not usual for the chimneys at collieries to be furnished with lightning conductors.

The CHAIRMAN: Some chimneys have lightning conductors, but there was none at the Rivin pit, I believe.

Mr. KNOWLES: No, we had none; it is but a small place.

UNDERGROUND HAULAGE AT THE ASTLEY AND TYLDESLEY COLLIERIES.

BY G. H. PEACE.

The subject of underground haulage is one of increasing importance, particularly in this county, where the greater depth of the mines leads to larger areas being worked from each shaft, and the economical transport of the coal from the working places has become a matter of paramount necessity.

The object of the present paper is more to direct attention to the general question than to lay special stress on the modifications and adaptations of the systems described, with a view of leading to discussion and in the hope that other papers may follow, as the writer is well aware that there are in operation more elaborate and extensive arrangements at some collieries in the district.

At the older and shallower pits of the Company, the

various systems of haulage comprise self-acting planes, single down-brow ropes, main and tail, and endless ropes; the engines in each case being placed underground, and supplied with steam from the surface boilers through pipes in the upcast shafts. In some cases horses are entirely dispensed with, and in others are used for hauling the coal from the workings along the levels to the main down-brow ropes.

At the deeper pits the objection to taking steam down from the surface was increased, and in the case of the Gin Pit, owing to its distance from any upcast shaft, it was not practicable, nor was it possible to fix boilers underground. The other alternatives were then very fully considered, and whilst admitting the convenience in working of compressed air, the much smaller first cost and economy in working of engines placed on the surface led to the adoption of the latter system with endless ropes at both the Gin Pit and Nook Pits.

The hauling engines at the Gin Pit consist of a pair of horizontal high pressure engines, with cylinders 10in. diam., 2 ft. stroke, geared $3\frac{1}{2}$ to 1, working at about 140 revolutions per minute, with a boiler pressure of 70lbs.

On the second motion shaft are placed two drums or driving pulleys, each 6 feet diam., with a clutch working between to enable either of them to be put in or out of gear. Each pulley has 4 grooves, and to obtain the requisite adhesion the rope is passed $3\frac{1}{2}$ times over the driving pulley, and a guide pulley with 3 grooves fixed in front of it, as shown in Figs. 1 and 2. By this mode of driving the friction on the ropes is reduced to a minimum, and if the guide pulley is set at a slight angle with the vertical plane, equal to the breadth of one groove, an absolutely straight lead is obtained for the rope to each groove.

The ropes are then passed round pulleys 6ft. diam. fixed

in the head gear and down the shaft in wood pipes, which are bolted to the horse trees. The main pump beam interfered with the pulleys being arranged under the pit brow.

One rope is used for hauling on the east side of the Crombouke Mine, and the other one for the Six Feet Mine, each being quite distinct from the other. Upon reaching the respective mines, pulleys are fixed in the shaft, and the rope is taken along the centre of the main way, round a pulley four feet diameter fixed on a tram with a tightening screw at the extreme end of the plane, and returns along the side of the road, carried on pulleys and wood rollers.

In each mine the system adopted is to run the tubs in trains or sets of from 30 to 40 tubs, the rope being carried upon the top of the tubs, and attached at each end of the train by $\frac{3}{8}$in. chains, about 7ft. 6in. long, which are wrapped two or three times round the rope and back-hooked.

This corresponds with the No. 2 system referred to in the Report of the Committee of the North of England Institute of Mining Engineers, and combines many of the advantages of the tail rope and endless rope, with only two-thirds of the length of rope required in the former.

The distance to the station in the Crombouke Mine is 1130yds., and in the Six Feet Mine 700 and 1300yds. respectively. The time ordinarily occupied in a journey from the shaft, changing at the end and returning, is from ten to fifteen minutes.

The coal is all brought to the main rope either by gravitation or by hand from the working places.

The tubs are of iron, and contain eight hundredweight of coal; the rails used are generally 21lbs. T rails in 8ft. lengths, with fish-plated joints.

The road is straight or nearly so, and slightly undulating, the steepest gradient being 1 in 20 rising towards the shaft. A single line is used in each mine, as the cost of making and maintaining the roads for double lines is much greater, and a sufficient quantity of coal can easily be hauled with the present appliances.

One of the principal items of expense in all underground haulage is the cost of ropes, and we attach great importance to the quality of the material and mode of construction of our ropes, and the wire is required to stand a severe test before it is made up into the rope.

The standard size adopted for the hauling ropes is $\frac{9}{16}$in. diameter of the best plough steel, and made with six strands. A secure and durable splicing cannot be made with a rope of less than six strands.

The ropes have not been in use so long as to determine the actual cost of wear and tear. The first rope, which was only $\frac{7}{16}$in. diameter, has now been working over three years, therefore in estimating the cost of any items not ascertained from actual experience, the course adopted by the North of England Committee has been followed.

The average quantity of coal hauled per day is 260 tons, but a much larger quantity can be brought out with the same cost for wages, at least 400 tons per day, which would of course materially reduce the cost per ton.

The cost of labour is as follows :—

	s.	d.	
One Engineman	3	4	per day.
Three Gang-riders	7	0	„
One Roadman	2	0	„
	12	4	

Cost of leading coals per ton, an average distance of 1040yds., 260 tons per day :—

	d.
Ropes	·262
Trams or Tubs	·100
Grease and Oil	·100
Coals	·140
Repairs to Engines, &c.	·100
Maintaining way	·050
Labour	·569
	1·321

At the Nook Pits we utilized a pair of engines for hauling, which are also used as capstan engines, with cylinders 12 in. diameter and 2 ft. stroke, geared 4 to 1, working at a boiler pressure of 45 lbs. to the square inch.

At these pits the system adopted is not quite the same as at the Gin Pit, instead of each rope being brought to the surface, only one, the main driving rope, works in the shaft, and from it are worked the branch ropes into each mine by means of grooved pulleys and clutch boxes.

The quantity of coal to be hauled in the Crombouke Mine is large and the distance too great to be dealt with conveniently on a single road, and a considerable portion of it being laid with two lines when horses were used, it was arranged to work the rope continuously at a slow speed, using one line for the full tubs and the other for the empty ones. This corresponds with the No. 1 system reported upon by the North of England Committee.

In the Six Feet Mine the distance is less and the quantity of coal wrought not so great, and a single road is used with one passing place half-way along the level. To obtain the alternate motion to work the rope in each direction, whilst the main driving rope works only in one direction, the driving rope is crossed between the two sets of pulleys in this mine, so that the pulleys revolve in opposite directions,

and each being provided with a clutch box, by putting either into gear the rope works in the direction required.

The main driving pulley on the second motion shaft is 6ft. diameter, with 4 grooves, and the guide pulley 4ft. diameter. The rope, which is of best Plough steel $\frac{3}{4}$in. diameter, works continuously in one direction and passes round two pulleys fixed at the top of the shaft, underneath the pit brow, to the Crombouke Mine, where a main shaft is fixed, upon which are two pulleys, one 6ft. and the other 4ft. diameter, and intended to have one or two more placed upon it when required. Each pulley has four grooves, the larger one is keyed on to the shaft, and the other one works loose upon it, and is fitted with a clutch box.

The driving rope passes round the larger pulley, and a corresponding guide pulley, and thence back to the shaft and down to the Six Feet Mine, where two sets of grooved pulleys, each 4ft. diameter, are fixed, returning round a tightening pulley, and up to the surface.

The speed of the driving rope with the engines making an average of 55 revolutions per minute is 3 miles per hour, reduced to 2 miles per hour in the Crombouke Mine by the proportionate size of the pulleys, the speed in the Six Feet Mine remaining 3 miles per hour, same as the main rope.

We have been at some disadvantage in having to adapt the existing roads for rope haulage, as they were not originally made for that purpose. In the Crombouke Mine the rope is carried round the curves at both ends of the slant, as shown on sketch, by deep flanged pulleys 4ft. 6in. diam., and at the lesser bends by small pulleys, also with deep flanges, carried from a cross bar at the roof. The road is undulating, which necessitates the use of lashing chains at both ends of the trains or sets, which consist of about 5 tubs, at short intervals, the rope being carried upon the top of the tubs.

A simple fence is provided near each pulley, consisting of a small wood bar, suspended across the rope, about ½ an inch above it, as shown on sketch, and it is further intended to enclose the pulleys in wrought iron casings, as those at the shaft are already.

The tubs are of wood, and contain 6 cwt. of coal. The first station in the Crombouke Mine is 1,270 yards from the shaft, the second 1,550 yards, and the third 1,760 yards, the total length being about 1,900 yards, and is being extended both along the level and down-brow to work out some deep coal, the rope passing round deep flanged pulleys at the top of the brow similar to those before mentioned.

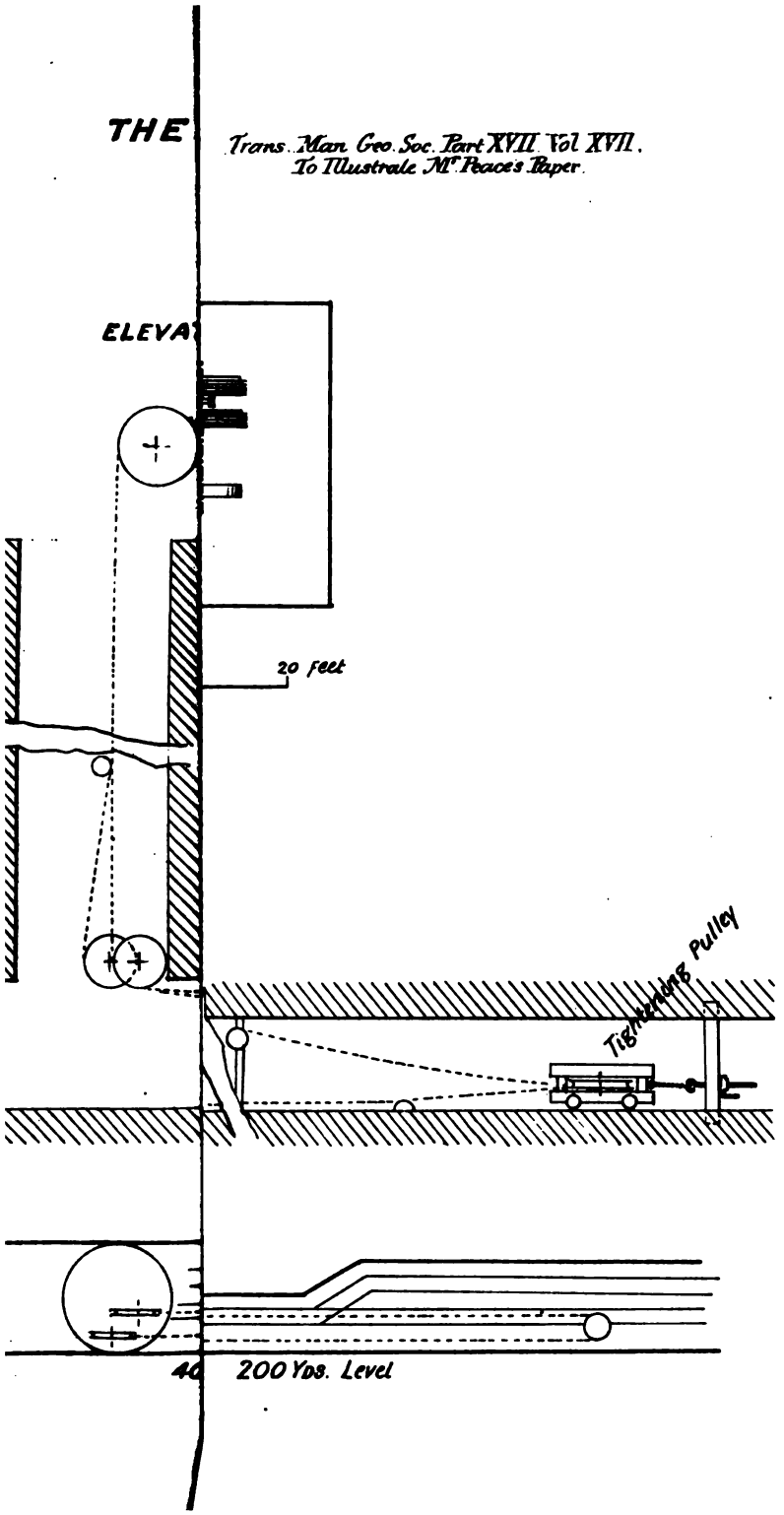
In the Six Feet Mine, trains, or sets of about 30 to 40 tubs, are brought at once, one train of full tubs leaving the far end at the same time that a train of empty ones leaves the shaft, the distance to the stations being 500 and 1,000 yards respectively.

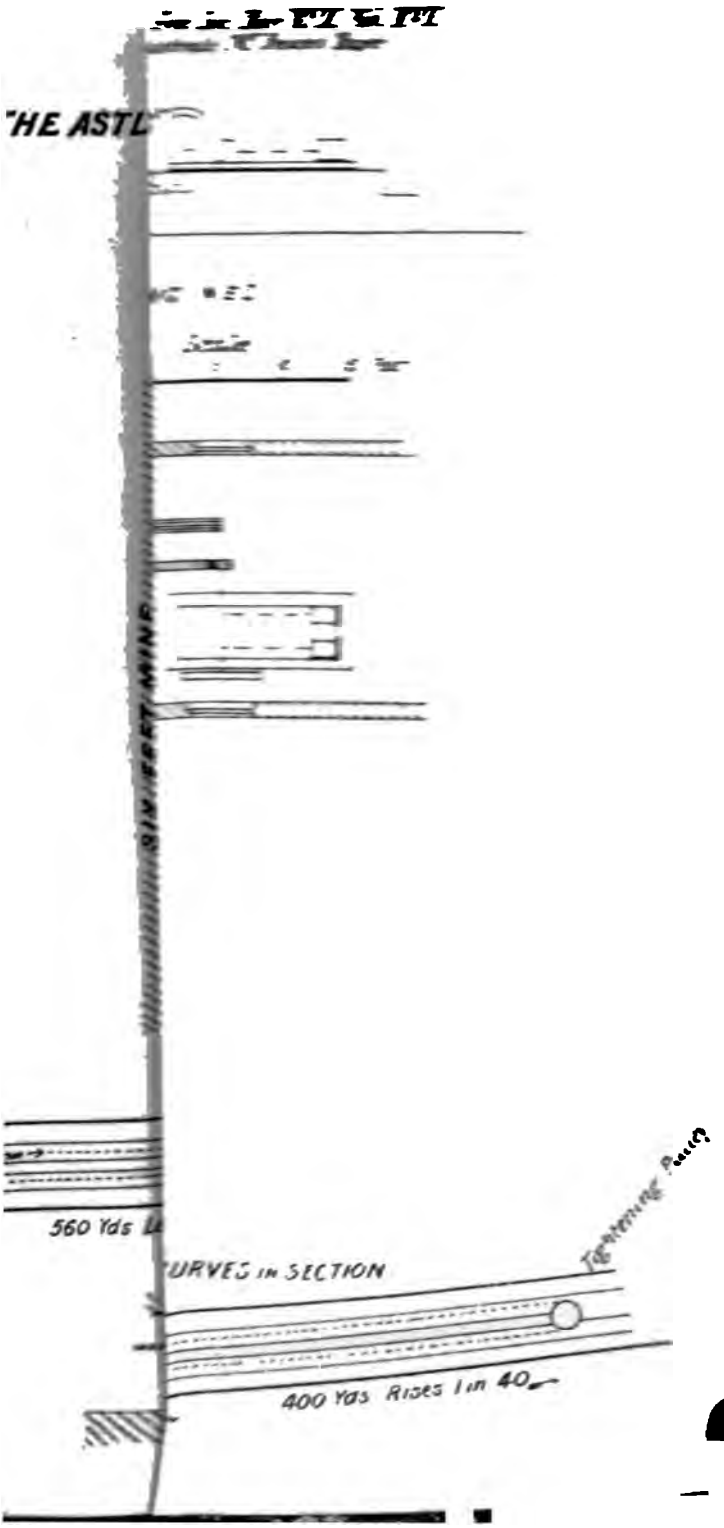
The coal is brought by self-acting planes or by hand to the main rope.

The average quantity hauled in the Crombouke Mine at present is 300 tons per day, but the capacity of this rope is practically unlimited. In the Six Feet Mine the average quantity is about 140 tons per day.

The cost of labour is as follows :—

	s.	d.	
One Engineman	4	0	per day.
Two Boys working clutches....	3	4	„
Two Gang-riders	5	8	„
Six Boys putting tubs on and off the rope, &c...	10	8	„
Three Roadmen	11	4	„
	35	0	


THE
Trans. Man. Geo. Soc. Part XVII. Vol XVII.
To Illustrate Mr. Peace's Paper.
ELEVA
20 feet
Tightening Pulley
200 Yds. Level


560 Yds
400 Yds Rises 1 in 40

Cost of leading coals per ton, an average distance of 1,400 yards, 440 tons per day.

	d.
Ropes	·316
Trams or tubs	·100
Grease and oil	·100
Coals	·129
Repairs to engines, &c.	·100
Maintaining way	·050
Labour	·954
	1·749

The CHAIRMAN: The fencing of the wheels, especially gig wheels when endless chains are used, has been a subject of considerable dispute in some parts of Lancashire—as to whether they did not entail more danger than they got rid of. In North Lancashire, where endless chains are used most extensively, they have settled the question that a fence round the gig pulley is an advantage; I think there is not a single gig not fenced now in North Lancashire.

Mr. J. S. BURROWS said they formerly used an endless chain at Atherton, but have given it up. They found the breakage of the chain, after it had been worn a little while, so annoying that they could not continue it. The same engine was doing more work with a rope, and they had never had a breakage yet, though it had been in use for four years. They did not go to the expense of new ropes; for this work the old winding ropes were used. He had seen Mr. Peace's arrangement, and it was certainly very neat and very carefully planned; but upon going into the question, and taking into consideration the plant required, where all had to be erected especially for this work, his conclusion was that there was very little gain in it. Circumstances, however,

required them at Atherton to put a pump down, and this gave them an opportunity of adopting the rope and doing away with horses. It enabled them to bring the tubs out in sets of about 10. The weight of the rope was a great item in the work which the engine had to do. The slower it was moved the more economical was the work done, and therefore they went in, as far as that level was concerned, for winding small sets at slow speed, with a great many tubs on the rope.

In answer to a question by the Chairman, Mr. BURROWS said that if they could knock off say eight or ten horses by the adoption of machinery for haulage it would be worth doing.

The CHAIRMAN: When you had these breakages going on in the chain, may I ask if the friction pulleys were so arranged that if any fall of roof interrupted the journey the machinery would stop?

Mr. J. S. BURROWS: No, there was no preparation at all. The roof in this particular case referred to was coal—which was very hard; the chain broke through the strain being too great.

The CHAIRMAN: In some collieries they are very particular to have friction pulleys, and they do not trust to these things being set right at the commencement, and their continuing so; but they test them each morning to see that they are in working order.

Mr. PEACE, in answer to the Chairman, said they had not at present any friction pulleys, but it was their intention to adopt them in any new work. They accomplished much the same purpose by having the ropes with as little tension on them as possible. If anything got fast it at once stopped the rope.

Mr. RIDYARD said he had not gone into the question fully. The Bridgwater Trustees, with whom he was con-

nected, were laying down extensive plant of this kind, but he could not speak definitely with regard to it at present.

Mr. TONGE said he was greatly in favour of haulage by the endless rope. He very much preferred the rope to the chain, in the first place, and very much preferred the rope to ponies almost under any circumstances. There were conditions under which it would be impossible to work by ponies—that was what first drove them to begin the endless rope system. They had a brow which rose from the pit at the commencement at the rate of about 1 in 14; it then was flat for about 70 yards, and afterwards fell from the pit 1 in 14, the whole length being 1,000 yards; and in the last 700 yards, where the coal had to be brought uphill towards the pit, they had about twelve ponies to bring the coal from little more than half way down, the remaining half being temporarily left. The brow was 700 yards down, but they were compelled to leave the bottom end for a while to bring the upper portion of coal; and he found that it would be quite impossible to employ sufficient ponies on that brow to bring the coal up. It therefore became a matter of necessity that they should have machinery. There was one difficulty they met with, namely, the brow dipping in two directions—three really, one being down hill towards the pit—the rope was stretched, and consequently became slack upon the driving pulley. That was the only real difficulty they had to contend with, and by putting on a second pulley, which they called a tightening pulley, at that end the difficulty was overcome. It was rather difficult at first, but by putting the rope in the form of the figure 8 round this tightening pulley they got a good deal of power. They had a three-groove pulley, and by that means got a considerable grip on the pulley. They were now bringing a considerable quantity of coal to the shaft, and had worked with one rope (Lang's patent) for four

years. That rope was still in perfect order, and it was running half a day at a time without stoppage. They had adopted the same system elsewhere, being so satisfied with it.

Mr. R. WINSTANLEY said he understood they used at Tyldesley grooved pulleys. He had also seen them in use in South Wales, at Rhymney, Scotland, and elsewhere. The wire ropes at these places wore out very fast indeed, and this was attributed to the grooved pulleys. He would like Mr. Peace to state what had been his experience on that point. At some collieries with which he (Mr. Winstanley) was connected they had endless rope haulage, with the ordinary "C" pulley; and they found the ropes last fairly well. They had had one rope about 2,000 yards long running over two years, and another nine months without its showing excessive signs of wear. In comparing the cost of pony labour with any other system of haulage it was necessary to consider the character of the mine. In the former case the roof must be of a certain height. In the Mountain mine where the seam was very thin; the haulage was carried on for great distances; and the cost of making the roof high enough for a horse or pony would, in many instances, be more than the expense of putting down haulage plant. There was another matter. He supposed, from Mr. Peace's sketch, that his haulage was driven from the surface; he (Mr. Winstanley) had found in some cases that it was far cheaper to drive from the bottom of the shaft, smaller power being required. He remembered an instance where with a pair of 9-inch engines placed at the bottom of the pit, a rope 2,000 yards in length was driven by means of a "C" pulley. The first length of rope had a rise of 1 in 10 for 300 yards to a right angle bend; then the road was level, and afterwards 700 yards of down-brow, dipping 1 in 10; there were several curves or bearings; and that haulage,

to the extent of 200 or 250 tons a day, was driven by a pair of 9-inch cylinder engines, of course geared up; and the "C" pulley would occasionally—say once in 18 months or two years—want taking out and turning up in the groove.

Mr. GRIMKE said that at the Bryn Colliery they had been obliged to put in this haulage. They considered compressed air preferable to steam, and moreover quite as cheap. They got a fair average out of it—he should think 85 per cent., though no exact calculation had been made.

The CHAIRMAN: 85 per cent. indicated horse power?

Mr. GRIMKE: 85 per cent. of what the engines in the mine would do worked by steam.—Replying to a further question by the Chairman, he said that if they took a pair of engines any distance from the shaft there was a large amount of condensation in the pipes, and consequent loss of power. If they came to indicate an engine on the surface, and again in the pit, they would find the results very different. They were generally put down at what they would do on the surface, but he maintained that an engine ought to be indicated in the place where it did its work—it might be 200 or 300 yards from the shaft. They found that wherever they took the steam pipes, down brow or on the level, the roof was perpetually falling, and the warrant troubled them; they therefore came to the conclusion that the air engine would save itself in that alone.

The CHAIRMAN said that the air engine had undoubtedly many advantages. The air was always of use in a mine, but steam had many drawbacks.

Mr. GRIMKE said they used almost entirely, for their engines, friction gear, which was quite as strong as an ordinary toothed wheel. There was no slipping if the engine was in gear.

The CHAIRMAN: The use of friction gear for these end-

less chains is that the friction may be set just so much as will move the load, and no more.

Mr. Cockson said that if he had known that this question would be discussed that afternoon he would have brought exact figures showing the comparative results of compressed air and steam; but he might state that at one of the Wigan Coal and Iron Company's Collieries they had an air compressing engine on the surface to do the underground hauling, but having decided to alter it to direct haulage by putting the boilers close to the furnaces underground, they were able to arrive at the consumption of coal required by the two systems. On the surface they required two boilers, and burnt twice as much fuel to do the work which was done by a single boiler underground, when they did away with the air compressor. We found it very advantageous to get rid of pony labour, and wherever that was possible it was done.

In answer to the Chairman,

Mr. Cockson said if they had boiler power already, and their roads could be made into engine roads without a very large outlay, he should say that, in point of wages, &c., it would pay them if they could do away with six horses.

Mr. J. S. Burrows observed that in his estimate he contemplated the necessity of putting down new plant altogether.

Mr. Peace, in replying upon the discussion, said Mr. Winstanley had asked a question with regard to grooved pulleys. Their experience of the "C" pulley had not been favourable at all. They had only one in use, and it was found that the cost of ropes for that particular pulley was very great; that led them to adopt the grooved pulley. As stated in the paper, one rope in the Gin Pit, 1⅛in. diameter, had been working over three years. As to the driving rope at the Nook pit he was hardly in a position to say what its duration would be; the wear and tear were greater—it had

to pass round so many more pulleys, and much more frequently. Then as to the question of engines at the bottom as against engines on the surface; in their case it was impossible to put them at the bottom, as they had no upcast shaft within 500 yards, and their experience as to the consumption of coal was very favourable. The only objection to their being on the surface was they had to take the rope down the shaft, but that extra length of rope was not useless; it enabled them to get more adhesion on the pulley, and the descending rope balanced the ascending one, so that no more power was required. With regard to compressed air, he had had no experience at all; but enquiries made from time to time as to the cost of putting down plant and the large consumption of fuel had led them to discard the idea altogether. They put their engines on the surface, and, so far, they had been quite pleased with the result. With reference to grooved pulleys he might add that when they adopted them they were not aware of their having been tried elsewhere except at the Bridgewater Trustees' Collieries; but when they had got their plant at work they found that similar appliances were used in South Wales, in Scotland, and at Wigan; and he was not quite sure whether they were not in use in the North of England also. There was an obvious advantage in members presenting their experience in the form of papers to be read at the meetings of the Society. They might profit by the results, and some of them might be saved many costly, and it might be useless, experiments.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XVII. SESSION 1883-84.

At the ORDINARY MEETING of the Members of the Society, held on Friday, the 13th day of June, 1884, in the Mining School Buildings, Wigan.

W. S. BARRETT, Esq., in the Chair.

The subject announced for the consideration of the meeting, was:

Discussion on Mr. Hall's Paper read on 1st March, on "What will the Royal Commission report as to Lighting and Blasting in Mines?"

The CHAIRMAN said that he regretted that there was such a meagre attendance. He felt sure there must be some special cause why more gentlemen were not present. There was a meeting on trade matters in Wigan at two o'clock that afternoon, and it was quite possible that many gentlemen might in consequence be unable to attend this meeting.

Mr. CALDWELL said he thought it would be best to adjourn the meeting.

Mr. UNSWORTH remarked that under the circumstances it seemed the only course they could take.

The Meeting was then adjourned.

The following are the recent additions to the Library:—

Cambridge University: Report of Museum and Lecture Rooms Syndicate for 1883. Chester: Society of Natural Science—Thirteenth Annual Report for year 1883–84; *From the Society.* Devon and Exeter Albert Memorial Museum: Fourteenth Annual Report for year ending April 14, 1884; *From the Committee.* Edinburgh: Royal Society—List of Members, 1883; *From the Society.* Edinburgh: Royal Physical Society—Proceedings, Session 1882–3; *From the Society.* Hunt's British Mining—A Treatise on the Metalliferous Mines of the United Kingdom; *Purchased.* London: Geological Society—Quarterly Journal, No. 158, Vol. XL.; *From the Society.* Geological Magazine, Nos. 239-240-241; *Purchased.* Geologists' Association—Proceedings, Nos. 5–6, Vol. VIII; *From the Association.* The Royal Society—Proceedings, Nos. 230–231, Vol. XXXVI.; *From the Society.* Society for Psychical Research—Part 5, April, 1884; *From the Society.* Manchester Literary and Philosophical Society—Proceedings, Vols. XX., XXI., XXII.; Memoirs, Vol. VII., third series, 1882; Memoirs, Vol. IX., A Centenary of Science in Manchester, Editor, Dr. Angus Smith; *From the Society.* Norwich: Geological Society—Proceedings, Part 8, Vol. I.; *From the Society.* Mining Institute of Scotland—Transactions, Part 9, Vol. V.; Transactions, Parts 1-2, Vol. VI.; Rules and List of Members; *From the Institute.* Institution of Mechanical Engineers—Proceedings, May, 1884; *From the Institution.* North of England Institute of Mining and Mechanical Engineers—Transactions, Part 4, Vol. XXXIII.; *From the Institute.* Midland Institute of Mining, Civil, and Mechanical Engineers—Transactions, Part 70, Vol. IX., 1883; Part 71, Vol. IX., 1884; *From the Institute.* Modern Progress of Mine Engineering—Pamphlet by Henry Bramall, M.I.C.E.; *From the Author.* South Wales: Institute of Engineers—Proceedings, No. 7, Vol. XIII., 1884; *From the Institute.* Science Monthly, Nos. 7 and 8, Vol. I.; No. 9, Vol. II.; *From the Editor.* New South Wales: Royal Society—Journal and Proceedings, Vol. XVI., 1882; *From the Society.* New South Wales: Report Sydney Free Public Library, 1883–4. Victoria: Reports of Mining Surveyors and Registrars, December, 1883. American Institute of Mining Engineers—Transactions, Index, Vols. I. to X. Canadian Institute, Toronto—Proceedings, No. 1, Vol. II., 1884; *From the Institute.* United States: Compendium of the Tenth Census, 1880, Parts 1 and 2; *From the Government, U.S.A.* United States: Department of Agriculture—Third Report of the Entomological Commission, 1883; *From the Government, U.S.A.* New York: American Museum of Natural History, Bulletin No. 5, Vol. I.; Ditto, Fifteenth Annual Report, 1883. Rome: Atti della R. Accademia dei Lincei, Transunti, Nos. 7, 8, 9, 10, 11, 12, Vol. VIII. Pisa: Atti della Società Toscana di Scienze Naturali—Processi Verbali, March 2, 1884, May 4, 1884; Indice del Vol. II. and III. Memorie,

Fasc. 1, Vol. VI., 1883; *From the Society.* Berlin: Zeitschrift der Deutschen Geologischen Gesellschaft, 4 Heft, 35 Band, 1883. Dresden: Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis in Dresden, 1883. Elberfeld: Jahres-Berichte des Naturwissenschaftlichen Vereins, Heft 6. Leipzig; Sitzungsberichte der Naturforschenden Gesellschaft zu Leipzig, 1883. St. Pétersbourg: Académie Impériale des Sciences—Mémoires, Nos. 10, 11, 12, 13, 14, Tome XXXI. Paris: Revue de la Législation des Mines, June, 1884; *Purchased.* Lausanne: Bulletin de la Société Vaudoise des Sciences Naturelles, No. 90, Vol. XX.; *From the Society.* Bruxelles: Nouvelles observations faites dans la Campine en 1883, *Brochure* par Ernest Van den Broeck; *From the Author.* Bruxelles: Mélanges Géologiques et Paléontologiques, *Brochure* par Ernest Van den Broeck; *From the Author.*

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